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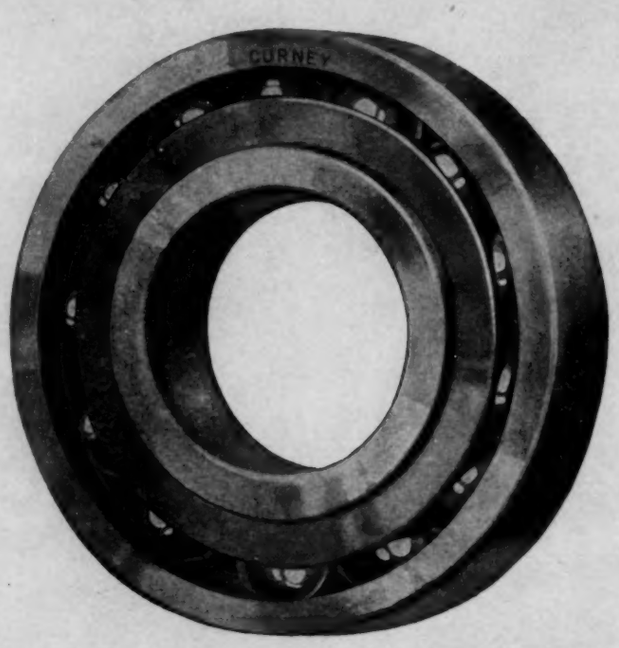

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Army Motor-Transport Vehicles

By JOHN YOUNGER,[1] PITTSBURGH, PA.

This paper contains a discussion of the types of vehicle best adapted to various military needs. Motor-transport vehicles have been classified by the Army under ten broad heads, ranging from the motorcycle to the 5-ton truck, and such a classification has been found to be a most satisfactory one. The ultimate ideal is of course to standardize a single type of vehicle for each class, and with that point in view the writer discusses the various vehicles used. Numerous photographs are presented as illustrative of American design and construction, and in the complete paper tables and curves will be found giving data on the various types used during the war.

IN considering the subject of motor-transport vehicles used by the U. S. Army the writer believes it is unnecessary to go into any detail regarding the history of motor-vehicle transportation in military use. It is of interest in passing, however, to note that steam vehicles were successfully used years ago, reaching their highest point of development in the British South African war. Motor road transportation does not come into great prominence again until the Great War of 1914, when its use exceeded the estimates of even the most radical. During the war motor vehicles were used by the tens of thousands. They paralleled the railroads, they crossed the railroads, they radiated in all directions. Motor trucks, loaded with shells in the Midlands, were driven straight to the channel ferry and run right up to the front line in France, without any changing of load, the saving in time being of course enormous. It is a matter of record that the fight for Verdun was fought and won largely through aid furnished by motor-vehicle equipment. The railroad was at the mercy of the enemy, and a military highway accommodating four streams of trucks was built, thus saving the city.

FIG. 1 STANDARD "B" TRUCK FULLY EQUIPPED FOR CARGO PURPOSES

These are matters of history pointed out principally to illustrate a new mechanical feature which has arisen in warfare. The successful army, as of old, is in large measure the one which possesses the characteristic of great mobility. The internal-combustion-engine motor vehicle has in the past decade accomplished a revolution in military mobility and it is proper, therefore, that attention should be directed to the technical features underlying this great change. However, to go into detail concerning their mechanical points would be merely to recapitulate their catalog specifications. It is felt advisable, therefore, to try to form some measure of classification so that the whole broad array of motor equipment, ranging from the small motorcycle to the huge 5-ton cargo-carrying truck, can be studied intelligently and with a view to seeing in what direction we should plan in the future to take care of our military needs.

CLASSIFICATION OF VEHICLES

Such a classification would be as follows below, and as the war progressed it was found more and more that this classification was a scientific one into which the various types of vehicles tended to concentrate, so that in the ultimate ideal there would be one standard-type vehicle in each classification. This particular point is one, however, which will be studied later.

1 Motorcycles
2 Light Passenger Cars, suitable for carrying five passengers
3 Heavy Passenger Cars (enclosed or limousine type) for carrying staff personnel
4 Ambulances
5 ¾-Ton Trucks, for carrying cargo or personnel
6 1½-Ton Trucks (either pneumatic or solid tires) for carrying cargo or personnel
7 3-5-Ton Trucks on solid tires
8 Trucks of the 4-wheel-drive type
9 Cargo-carrying truck-laying type of vehicle
10 Trailers—¾-1½-3-5 or 10-ton.

SPECIAL ARMY REQUIREMENTS

Before proceeding with a discussion in detail of each of the types in the foregoing classification, it would be well to consider whether the Army has or has not special requirements which render necessary the special design in their equipment. The inability of the motor vehicle to work economically on poor roads has called forth a general demand for improved highways which has resulted in the spending of millions of dollars on state highways this year alone. These state highways are chosen in location just as the railroad is—because of the economic purpose the road will serve, either in our commercial life or in our recreation. The very small minority that operate pleasure cars on poor roads have to pay the

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penalty, and even more so with motor trucks. A great volume of business lies in the cities where exceptionally good roads are met, whereas the number of trucks operating outside of the cities is very small.

The problem of the Army, however, is different, for rarely, if ever, does it operate in a big city, its operations being confined to the open country. It has to take roads as it finds them and sometimes it has even to make its own roads. In this connection it is of interest to examine the roads on the borderlands between this country and Mexico and to observe that they actually barely exist. The needs of the Army must therefore be considered from the military standpoint and neither political nor commercial considerations should be allowed to block the main issue, namely, that the Army must have proper motor transportation suitable to insure its mobility under any possible circumstances in which it will be called to fight. Stress is laid on this point as there have been arguments pro and con as to the advisability of the army using commercial vehicles. The war in France brought little light on this subject because for years the battle line was practically stationary

FIG. 2 ORDNANCE DESIGN OF 4-WHEEL-DRIVE "TRACTOR-TRUCK"

and the country behind the lines had innumerable highways of high-grade construction of an antiquity reaching back way beyond the days of Napoleon—actually to the days of Julius Cæsar. The motor vehicle, therefore, for military use should be considered from the military aspect and we should not necessarily try to foist on the Army vehicles which are of proven value only in the commercial field.

DISCUSSION OF TYPES

Motorcycles. These proved of tremendous use in warfare. Where despatches had to be carried over exceedingly rough ground, where high speed was essential, where transportation under fire was necessary, the motorcycle proved its value. Two of the commercial makes of motorcycles manufactured in this country proved that in general they were satisfactory from a military standpoint. Military use, it is true, developed certain weaknesses which were ultimately remedied, but the experience of the war indicated that the present-day motorcycle of standard construction suitable for side-car use would survive as a standard of equipment, and that a light-weight machine—not over 250 lb. in weight—should be developed for "solo" work.

Light Passenger Cars. Two American machines were used in great quantities, the Ford and the Dodge. Both gave good satisfaction, but it is felt that still better satisfaction could be obtained by concentration on one passenger machine of a somewhat more rugged design. There are, however, commercial aspects in this case as machines such as the above have a tremendous market off the beaten highway and their economic and satisfactory use by farmers and the like over poor roads, or over no roads at all, furnishes sufficient test to warrant the army considering very seriously in this case the commercial vehicle. On the whole, it was found that the car of the Dodge type gave the most satisfactory results. This type of vehicle was used for officers in their work involving the covering of territory, in the transportation of light supplies, as an emergency repair wagon, and in all kinds of ways which will suggest themselves to any student of military affairs. It is the writer's personal opinion that there is no necessity for two types of cars—one type alone will be ample. Only in cases of sudden emergency, where a tremendous increase in the army would be required, would it be advisable to increase the number of types.

Heavy Passenger Cars. For staff use it is essential that a more powerful car, capable of maintaining a high speed over long distances, should be provided. This car should be preferably of the sedan or limousine type to insure comfort to the occupant. The staff officer in directing troop movements is often required to make long journeys at night in such a car, and all facilities should be provided to insure rest. This car should be provided with facilities for carrying maps, reports, etc., and with necessary lights so that such could be studied during the night. This car will only have a limited use and will be used almost exclusively along the highways, so that a commercial type of car would be quite suitable. During the war the Cadillac was used exclusively for this purpose by the American Army and its specifications would stand today as being typical of what would be required for future use.

Ambulances. The ambulance is a peculiar type of vehicle in the sense that while its load consists of only four or five passengers, the shape of the load (the patients, of course, being recumbent) necessitates almost a box-van construction for the body. Furthermore the fact that the patients have to be carried with great care necessitates special attention being paid to the springing and the comfort generally of these vehicles, particularly when it is realized that they must operate as closely as possible to the firing line and in all probability some distance away from the good roads, and subject to shell fire. The writer feels that for this purpose the chassis used for passenger carrying is one which will be found most desirable for this use, with a possible change in the direction of lengthening the wheelbase to insure better adaptation to the body.

During the war there were two types of ambulances used, one a simple 4-patient ambulance mounted on a long-wheelbase Ford chassis; the other, a more elaborate one mounted on the ¼-ton G.M.C. truck. Both ambulances had their distinct use, the Ford type being used close to the firing line, while the G.M.C. was used more behind the lines from the rest stations to the base hospitals. In view, however, of the limitation in number of our standing army, it is believed in the interest of concentration of equipment that it would be advisable to have only the one chassis used for this purpose. It is felt unnecessary to go into the details of this chassis.

Passenger-Carrying Heavy Vehicles. The passenger-carrying heavy vehicle calls for special mention as it differs from the cargo-carrying type. In connection with artillery work it is necessary to carry a band of men for special work. Reconnaissance also calls for a crew of men to go out with range finders, various binoculars, instruments and tools for marking so that a proper site can be selected for the placement of field guns. The vehicle for this purpose must be provided not only with seats carrying the necessary personnel, but also with proper compartments for carrying the various tools required. The vehicle for this purpose should be capable of traveling over rough ground and should be, as are the others, of sturdy construction. Another type of passenger-carrying vehicle is what is usually known as a staff observation car. This is a large car — sometimes of the omnibus type — in which as many as nine or more passengers can comfortably be carried. This is used on occasions when the staff, particularly in the artillery, wishes to make an observation run or for the purpose of visiting

different posts. The 1½-ton cargo-carrying chassis with pneumatic tires is quite suitable for this work.

The ¼- and 1½-Ton Pneumatic Tire Trucks. The ¼- and 1½-ton pneumatic-tire trucks can be grouped together as their work is very similar. A high state of development was found in these capacities of commercial trucks from the Army standpoint, this being most certainly a result of the fact that both these capacities are used in large numbers in country districts where bridges and other limitations do not interfere with their use. These vehicles are used for carrying modern loads, the smaller size being used for emergency repair work, carrying emergency stores, and for final distribution of supplies from the main dump or from one or other of the advanced stations. They are also used in large numbers in connection with the Air Service, furnishing supplies of all kinds not only for the airplanes but for the personnel. Airplanes, of course, had their stations off the road in the fields, and naturally the lighter trucks were found necessary.

Special attention is called to the use of pneumatic tires. It was found in trucks up to 1½-tons capacity that pneumatic tires allowed running on very poor roads and over comparatively soft surfaces, such as a grass field, under conditions that would have prohibited the use of solid tires. It was also found that high speeds could be maintained for long periods with practically no damage to the vehicle. For example, a 1½-ton capacity cargo truck could be driven at a speed of 30 m.p.h. over give-and-take roads for long periods. This, of course, has a tremendous value in mobility and also in emergency cases where supplies can be rushed forward. Under certain conditions, such as operating over sandy roads (as are found in many parts of the country), these moderate-capacity trucks with large pneumatic tires would be practically the only trucks that would be of any value.

Much discussion has ranged over the use of pneumatic tires, whether they should be single or dual on the rear. European prac-

FIG. 3 EXPERIMENTAL TYPE OF TRACK-LAYING AMBULANCE USING THE FORD CHASSIS

tice has been to use dual tires on the rear, the front and rear size being the same, thus eliminating the necessity of carrying two spare tires and tending toward interchangeability. American practice has been to use one size of tire on the front, such as for example, 38 in. by 7 in. and a larger (40 in. by 8 in.) single tire on the rear. Both types have worked out successfully during the war and it is felt that a little longer period of development is necessary before a decision could be arrived at as to which is likely to be the surviving type, if not both.

The 1½-Ton Solid-Tire Trucks. The 1½-ton cargo-carrying truck with solid tires can be looked upon in the Army as the maid-of-all-work. Cargo of all kinds, men, supplies, food, and munitions are carried on this steady-going vehicle. This is the vehicle which has in motorized equipment taken the place of the standard mule escort in the old Quartermaster Department. Able to run at 16 m.p.h., of sufficiently light weight that it can go over any average bridge, thoroughly worked out over a period of years in commercial life, in the Army found but little change necessary in adapting it for their purposes. In the selection of one type for standardization it was found very difficult to distinguish which among a number was the best, and it is no slur on any of the types not approved when, for various reasons not always connected with their technical worth, they were rejected.

The 3-5-Ton Cargo-Carrying Trucks. The 3-5-ton truck was not used during the Mexican War and it remained for the Great War to establish its status as one of the standard vehicles of the Army. It was around this capacity of truck that tremendous discussion raged during the early stages of the war. The Army, in considering the various heavy capacity trucks on the market, came to the conclusion that these were unsuitable for military use. The

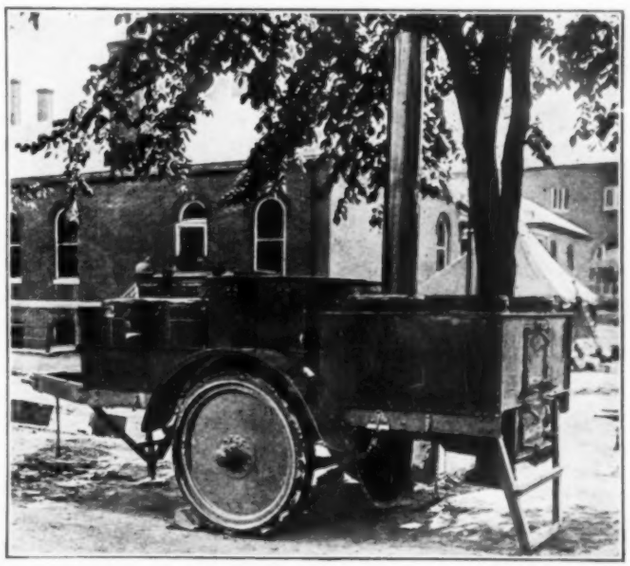

FIG. 4 ARMY ROLLING KITCHEN READY FOR MOVING

5-ton truck of commerce is used almost solely around the cities. Bridge and load limitations have been, of course, partially preventive of its use in outlying districts, but the big obstacle has been the fact that the industry requiring a truck of this capacity is almost invariably located in the larger cities and requires this purely for city use. The commercial vehicle of this capacity has therefore been developed, consciously or unconsciously, along good-road conditions. It was found that, in operation over poor roads, it had insufficient ability to proceed at a regular speed through heavy mud holes or heavy winter conditions. This point will of course be argued by those responsible for the average heavy-capacity truck, and while it is true that such trucks could operate under such conditions, the penalty paid was nevertheless tremendous.

For this reason, the Government saw fit, in 1917, to design and develop a truck of its own, this being known variously as the "Liberty" truck or "B" Type truck, the latter being its official title. Fig. 1 shows this truck fully equipped for carrying cargo. It was developed by the coöperative efforts of the engineers of the industry and the Government and was put into production, approximately 18,000 being manufactured to meet the demands. In this vehicle the special points that were required by the military use were built into the truck and were not added as an afterthought. The ability of this truck (piston displacement per 1000 lb. moved 1 ft.; or the torque at the rear wheels' circumference) is approximately 50 per cent greater than that of similar capacity in commercial trucks. This is more noticeable on the low or first-gear drive. In driving around on the various trucks, watching their performance under heavy conditions, one could not but be impressed with the ease with which this truck operated over extremely heavy going.

This capacity of truck was developed as a larger brother to the

1½-ton truck. Its military advantages were not at first seen but later they became obvious. Its overall length was less than 10 per cent greater than that of the 1½-ton truck and similarly with its width. Carrying two or three times as much cargo as the smaller truck, it offered virtually the same target on the road and in convoy work was almost 66 per cent less in length. From the standpoint of what might be called the direct labor problem of the Army, the number of men required to operate the heavy truck was exactly the same as that for the lighter truck; thus, for given amount of cargo it released more men for the firing line. The work of repairing, the number of spare parts necessary, maintenance and cost of running were also almost identical with those of the lighter truck and it is not surprising, therefore, to find that although this class of truck was introduced in the Army at a late date, it made tremendous strides, outnumbering any other capacity of truck. Another advantage that showed itself, due to capacity and ability to put on large platforms, was that this vehicle offered means of using trucks for all kinds of work where mobility was essential.

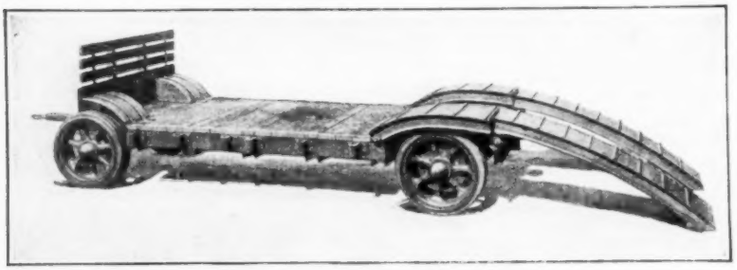

FIG. 5 ARTILLERY 10-TON TRAILER FOR TRANSPORTING TRACK-LAYING TRACTORS, SMALL TANKS OR GUNS

FIG. 6 ORDNANCE MOBILE REPAIR SHOP

It is felt that this "B" type truck will be the standard heavy cargo-carrying truck for the Army. It will undergo normal developments with time, and, in peace conditions, prove itself of tremendous value in military operations. During war times, if there be any kind of highway system, it will also demonstrate its value. It is also believed that, with the proper organization and with the proper help from the Engineer Corps in improving the existing highways and bridges, it will be able to operate almost anywhere that the army operates.

The 4-Wheel-Drive-Type Truck. The 4-wheel-drive truck shown in Fig. 2 is that type of vehicle in which the driving power is conveyed to all the four wheels and in which the full weight of the truck is available for traction purposes. Sometimes this type of truck steers on all four wheels, and sometimes only on the two front ones. Almost invariably, however, there is some type of differential locking or partial locking device which insures power being delivered to each wheel, whether or not that wheel is on a slippery or hard surface.

This type of truck is also subject to great argument; either its users are very strongly for it or they are very much against it — there seems to be very little middle ground in the discussion. On analysis, the reason for this shows itself. In military work and in emergencies it is essential that certain supplies be carried from one point to another, no matter what the terrain may be like. Sometimes the conditions are so bad that men must carry the supplies themselves or by mules; sometimes the conditions, while severe and absolutely prohibitive of the use of the ordinary vehicle, will yet allow the use of the 4-wheel-drive truck. With driving chains on all four wheels and with an extremely low-gear reduction, every ounce of power is available for traction and the 4-wheel-drive truck accomplishes its mission. Feats like these of regular daily occurrence in the Army have made military people, particularly in the Ordnance Department and Artillery Corps whose work is mostly "off-road," staunch adherents of the 4-wheel-drive truck. It must be realized, however, that during this work the strain on the truck is enormous. Only the heaviest jobs are given to this type of vehicle and under these severe conditions, it is not difficult to understand that the maintenance problem is tremendous. It is from this last viewpoint, in comparison with the 2-wheel-drive vehicles, that the 4-wheel-drive type has suffered, and suffered, it must be said, unfairly. Over good or reasonably good roads there is no necessity for a 4-wheel-drive type of truck, but over almost impassible roads the 4-wheel-drive truck will justify its existence. In the service of the Marine Corps, for example, where weight limitations are necessary and where the ability to go anywhere is essential, the 1½-2-ton capacity 4-wheel-drive truck is standard. It should also be noted that the 4-wheel-drive type of truck proved its value as a tractor for hauling guns over roads where the track-laying type of vehicle was almost prohibited. In hauling trailers and in the general haulage work required, this 4-wheel-drive type of vehicle became a necessary part of the equipment.

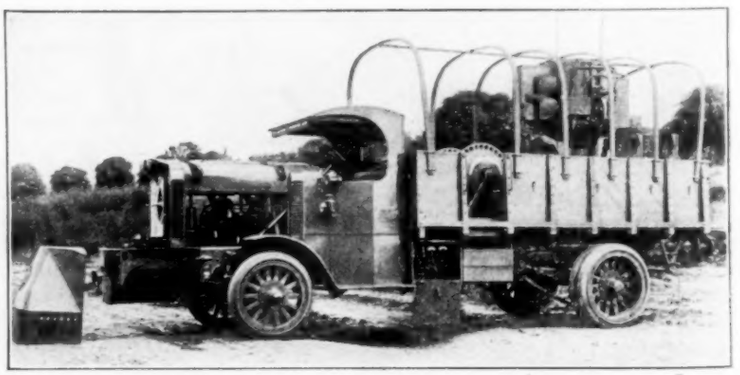

FIG. 7 SEARCHLIGHT EQUIPMENT USED BY ENGINEERS CORPS, MOUNTED ON SPECIAL 6-TON CHASSIS

Track-Laying Cargo-Carrying Trucks. First of all, this type was developed for agricultural-tractor purposes, the idea then being seized upon and used by the British in the design of their tank. It was natural that the caterpillar of track-laying type of vehicle should eventually be discussed in its relation to carrying cargo over "off-road" conditions. As practically all production capacity was used in the manufacture of tanks and what spare capacity there

was, was used for agricultural tractors it was almost impossible to develop the cargo-carrying track-laying type of vehicle during the war, but all indications pointed to the necessity for considering this design very seriously for the future in order to still further attain the ideal of perfect mobility. Small progress was made however, but still enough to show that the attention of military designers should be directed largely to this type. For winter conditions, for example, this may be found necessary; and for shell-torn fields, otherwise impossible to traverse, a track-laying vehicle may give the solution of the problem of transportation. One drawback to its use at present is the fact that over hard roads the wear and tear on the vehicle is greatly exaggerated and the maintenance problem is very severe. There is no question, however, but that these mechanical problems will be solved in time. An interesting application of the track-laying type of vehicle is shown in Fig. 3.

Trailers. These vehicles, strictly speaking, are not automotive vehicles, but their use is so linked with the others that it is necessary to consider them all together. Broadly their capacities fall under the same headings as do the cargo-carrying trucks, but experience has demonstrated the necessity for a much heavier type of trailer of the capacity of 10 tons. Apart from the commercial use of trailers they were first used by the Army as a means of getting around the shortage of engine-transmission and motive-axle production, in other words, to furnish some means of transportation. It was later found that apart from this, they were of great value.

Their use is indicated where extreme mobility is not required, as certain functions of the Army can be carried out, not on the firing line, but at a more or less permanent base. For example, advance repair shops need not be as mobile as the fighting army, but rather sufficiently immobile so as to allow the work being done. There should be, however, sufficient mobility to allow of eventually catching up with the advance forces. Such equipment as small repair shops, camp kitchens (see Fig. 4), partially mobile offices, X-ray surgical laboratories, cranes, etc., can also be conveniently mounted on trailers.

Other uses of trailers are indicated where for special reasons the truck or tractor is insufficient; for example, a field gun mounted on its own wheels is not able to traverse mile after mile of hard road at high speed. It is, therefore, advisable to draw this gun

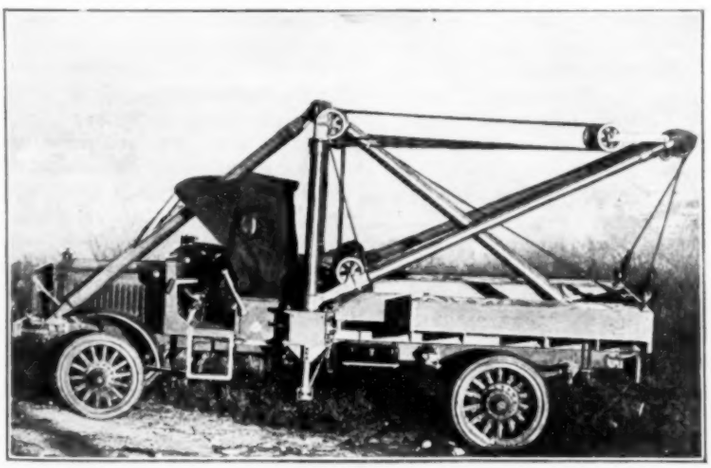

FIG. 8 A SPECIAL TYPE OF WRECKING APPARATUS MOUNTED ON A "B" TRUCK

on the trailer platform such as shown in Fig. 5 and tow it behind the truck. Similarly, tanks and caterpillar tractors were prohibited from traveling along the French roads, due to the damage they were said to create, and furthermore it was found advisable, on account of their slow speed, to have them proceed at a much faster pace. They were, therefore, also driven under their own power on to the platform of a trailer and towed along the roads at a comparatively high speed. In addition to the foregoing there is also a certain use in connection with ordinary cargo-carrying trucks, where a small number of trailers have been found advantageous in helping out the trucks in the carrying of supplies.

It is believed that standardization of trailers for military use will have to proceed along somewhat different lines than the standardization of trucks. The trailer is especially for emergency uses and all kinds of special work, whereas the platform will vary with the requirements. There is no reason, however, to prevent the standardization of the running gear, such as, for example, the structural framework, the axles, springs, wheels, etc., and the draft gear for towing.

There will undoubtedly be discussion as to whether 2-wheel-drive trailer or 4-wheel-drive type trailer will be advisable. The solution of this is again limited by lack of experience and information which will have to be digested, analyzed and the result derived therefrom. It would appear as if the 2-wheel type of trailer will be of value in the smaller size and the 4-wheel type in the larger size from 2 tons upward.

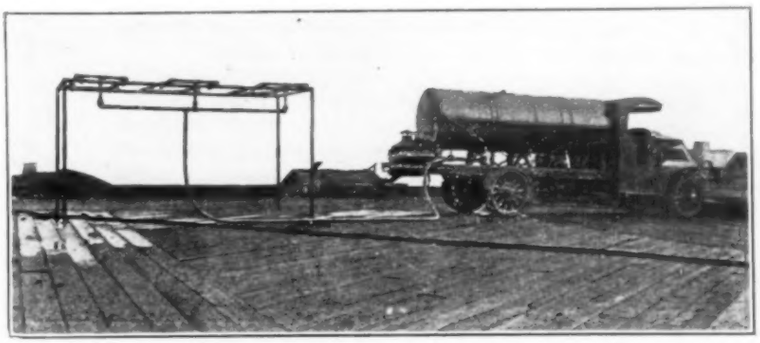

FIG. 9 MOBILE SHOWER BATH, DEGASSING OR DELOUSING OUTFIT

SPECIAL TYPES

In the military use of motor vehicles, first of all for cargo purposes it became obvious to inventive minds that here was not only an idea which would enable functions previously carried out in a slow way to be speeded up, but an idea which would establish new function. Special vehicles were asked for and were produced; mobile repair shop (see Fig. 6), vehicles carrying searchlights driven from the engine of the truck as generator, searchlights carried on the platform of the truck operated from their own engines (see Fig. 7), chemical laboratories, vehicles for the special purification of the water supply, photographic laboratories, lithographic laboratories, vehicles in which the power of the engine was geared to a large winch for the maneuvering of large observation balloons or to a crane thus creating a wrecking car (see Fig. 8), vehicles with integral wireless apparatus, with X-ray apparatus, with special tanks and pumping equipment and heating equipment for degassing and delousing soldiers, disinfecting vehicles, laundry vehicles, etc. Where action was necessary these thoroughly mobile vehicles could be brought forward at once.

An interesting case is that of the "degassing outfit," shown in Fig. 9. It was found that the effects of mustard gas could be greatly minimized, if not altogether prevented, by treating those exposed to a heavy shower of warm water shortly after contact. The soldier would be stripped, given a hot shower, under pressure, for about fifteen seconds, then sprayed with liquid soap, then lathered, then washed off; the whole operation taking about one minute. He would then receive new disinfected and deloused clothing and a new gas mask and be fit for immediate service again. A large tank

(*Continued on page* 892)

Scientific Development of the Steam Locomotive

By JOHN E. MUHLFELD,[1] NEW YORK, N. Y.

Despite the fact that marked progress has been made in the development of the steam locomotive, there still remains considerable opportunity for further improvement, and the general lines along which such improvement should be made form the supporting data of the following paper. The author first briefly outlines the factors involved in the determination of the tractive power of a locomotive. He next discusses such items as boiler feedwater, types of fuel, combustion, heat distribution, steam pressures, superheating, and steam generation and utilization. The acceleration and deceleration of a locomotive are also considered, and the paper is concluded with a discussion of the methods of saving fuel and labor, both of which should produce a higher standard of operation and economy.

STEAM railroads, to be successful, must, through executive foresight and engineering progressiveness, respect the same law of additions and betterments that applies to other profitable industries and which demands continuous modernization of plant and equipment in order to effectively and economically meet the necessity for greater production and speed by means and methods that will result in the least possible artificial age being capitalized in the improvements when installed.

Marked progress has been made in the development of the steam locomotive as the result of superior engineering ability, and the results have in many respects been exceedingly effective. This progress, however, has been confined largely to an increase in size, weight, evaporation capacity and hauling power, and while the general use of superheaters and firebox baffle walls during the past ten years has substantially assisted in improving sustained boiler capacity and increasing thermal efficiency as well as in keeping the steam locomotive in advance of the electric locomotive, the opportunity for further improvement in thermal and machine efficiency and to reduce smoke, cinders, gases and noise is untold.

The desiderata in a steam locomotive may be summed up as: a reasonable first cost; maximum capacity for the service within roadway weight, curvature and clearance requirements; ability to handle the heaviest gross tonnage practicable at the highest permissible speed; positive control of mechanical operation; economy as regards fuel and water consumption and repairs; minimum manual labor for road and terminal handling; construction of the least number of parts, and capacity to perform continuous mileage without failure.

Modern types of steam locomotives fulfill quite satisfactorily all of these requirements with the exception of wastefulness in fuel, water and steam consumption as may be gathered from the fact that the thermal efficiencies now obtained are only from 50 to 65 per cent at the boiler, from 60 to 75 per cent for combined boiler and superheater, and from 4 to 6 per cent at the drawbar. These as compared with thermal efficiencies of from 3 to 5 per cent at the drawbar of an electric locomotive, 18 to 19 per cent at the switchboard of a modern steam-electric central power station, 25 to 30 per cent for internal combustion engines, and 40 to 45 per cent as claimed for the full range of from one-quarter to full load for combination internal-combustion and steam motors.

The increase in the first cost and in the cost for labor, fuel, material and supplies for operation and maintenance of the steam locomotive has been most marked during the past ten years, particularly since the war. It is now being operated and maintained by highly paid enginemen and mechanics, with high-priced materials and supplies, and the machine and its performance must be brought up to a more respectable basis of engineering efficiency if it is to be perpetuated.

The supporting data of this paper, which apply to the United States, present the reasons why the general improvement of the steam locomotive should embrace the following changes which, it may be opportune to here state, are now being embodied in the design, specification and construction of a new type of locomotive, the first of which it is planned to have in regular service in 1920 on a prominent and progressive Eastern railroad:

a Steam at a pressure of about 350 lb. to be employed, superheated to about 300 deg. fahr.
b Improved boiler, furnace and front-end design and appliances
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In this country the steam locomotive has not been classified as a refined piece of engineering mechanism, such as a marine or stationary steam engine, due primarily to the indifferent conditions under which it has had to be operated and maintained and the relatively low cost for its fuel and supplies. However, with existing public demands for greater safety, speed, comfort, efficiency and economy in the movement of traffic, only by greater refinement in construction can requisite operating results be produced to offset the increased cost of equipment, supplies and labor.

Therefore the designing should now be done along more scientific lines through the substitution of boiler, cylinder and drawbar horsepower and drawbar-pull calculations for tractive power; thermal efficiency for evaporation results; distributed for centralized thrusts, strains and stresses; light high-grade alloy and high-carbon steels and other metals for heavy low-grade plates, forgings and castings; and in the more general use of high-grade engineering practice in lieu of rule-of-thumb methods.

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Factor of Adhesion. The coefficient of static friction or adhesion between driving wheel tires and very dry, clean rails reaches a maximum of about 0.35, and for moist, muddy, greasy and frosty rails a minimum of from 0.15 to 0.20, giving factors ranging from 2.85 to 6.65.

In general, the factor of adhesion should be as low as practicable, in order that the maximum power will always be available to start trains that can be easily handled when in motion, and should about equal the ratio between the limiting friction in pounds and the weight on driving wheels in pounds, which, for average dry rail is from 3.5 to 4.

Tracking, Curving and Riding

With the increased length, higher center of gravity, extended front and back overhang and smaller proportion of spring-borne weight there have been many difficulties to overcome in order to maintain proper tracking, curving and riding qualities in locomotives of great power, and in the majority of cases these have been met with unusually satisfactory results.

As the reciprocating forces must be neutralized by means of a revolving body, which cannot produce a perfect balance, it is of the greatest importance that every allowable effort be made to reduce the weights of pistons, crossheads and main rods and divide all weights as uniformly as practicable over all driving wheels, in order that excess balance may be reduced to the minimum and the greatest possible static weight permitted on the driving wheels.

Boiler Feedwater

No item in the operation and maintenance of steam locomotives contributes to greater unnecessary cost than boiler feedwater containing excessive incrusting, corrosive and foaming elements.

Observations and experiments indicate that any scale porous to water has little effect on boiler economy. However, such scale when dried out or hardened next to the metal by the expulsion of the carbonic acid, as usually occurs when boilers are forced, will not only become an excellent heat insulator and cause a heat loss of about 10 per cent when ⅛ in. thick, but it exposes the sheets and staybolts to overheating and "mud burning," with resulting leakage and shopping for repairs and cleaning.

In view of the increasing size of locomotive boilers and the high ratings to which they are subjected, the importance of purifying unsuitable water to prevent incrustation, corrosion, leakage and burning, as well as to eliminate delays and cost for cleaning, repairing and extra fuel consumed, cannot be overestimated, and until the many existing conditions of this kind are corrected, neither the existing nor improved steam locomotives can be expected to render satisfactory and economical service.

Boiler-Feedwater Purifying

When an adequate and suitable supply of boiler feedwater cannot be obtained from the usual sources, then the proper treatment of the available unsuitable water becomes necessary by settling; filtration; chemical treatment in treating plants, supply tanks or tenders; or, in the case of suspended matter and carbonates, by partial purification in a combination open and closed type of exhaust-steam feedwater heater on the locomotive.

Fuel

The principal fuels now used in steam locomotives are the commercial grades of bituminous and anthracite coal and fuel oil. While millions of tons of the by-products of anthracite and bituminous coal mining are available, as yet practically no progress has been made in their utilization, although satisfactory means and methods are now developed. This applies as well as to the enormous deposits of sub-bituminous coal and lignite that are only awaiting mining operations to come into their effective and economical use as locomotive fuel.

Regardless of the kind of fuel now used by steam locomotives, more general attention is being given to its proper preparation for the class of service to be performed and the method of firing to be followed, before it is supplied to tenders. However, the factors of kind and size of coal and method of firing must each be carefully considered and coördinated in order to insure the best results as may be shown by Table 1, which gives comparative performances of a stoker-fired modern Mikado type of locomotive with superheater and firebrick baffle wall supported on water circulating tubes.

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Item	Test No.	1	2	3	4
1	Coal, kind	Bituminous	Bituminous	Bituminous	Bituminous
2	Coal, class	Gas	Gas	Soft	Soft
3	Coal, grade	Nut, pea and slack	Slack	Run-of-mine	Screenings
4	Coal, moisture, per cent	1.23	1.57	0.75	0.81
5	Coal, volatile, per cent	36.47	35.74	18.17	17.52
6	Coal, fixed carbon, per cent	53.94	52.78	69.07	70.06
7	Coal, ash, per cent	8.36	9.91	12.01	11.61
8	Coal, sulphur, per cent	2.59	3.30	3.33	2.31
9	Coal, B.t.u. (calorimeter)	13,910	13,790	13,880	13,970
10	Total miles run	505	505	505	505
11	Kind of firing	Stoker	Stoker	Stoker	Stoker
12	Pounds of coal per average drawbar hp-hr.	3.74	4.19	4.14	4.89
13	Boiler efficiency, per cent	46.60	41.90	46.10	38.00
14	Relative pounds of coal fired, per cent	100	111.87	110.54	130.56
15	Relative cost of coal, per cent	100	102.14	123.58	143.64

It will be noted from Table 1 that while the heat value (Item 9) of each of the four fuels tested was practically the same, there is a difference of over 30 per cent in the quantity fired, and of over 43 per cent in the fuel cost for the same work done, when comparing the poorest with the best performance, and that the use of either grade of soft coal is absolutely prohibitive so long as either grade of gas coal can be obtained.

With the cost for locomotive fuel on tenders practically doubled during the past two years, and next to labor the largest single item of railway operating expense, the best methods for its use will now begin to receive the consideration that this large item of operating cost justifies.

Combustion

A comparison of the figures of 65 years ago with the average saturated-steam-locomotive performance of today will show little improvement has been made in the average road service.

The locomotive fuel bill for the year 1918 was approximately $750,000,000, and while full recognition is given to the fact that from 25 to 50 per cent of the available energy in the fuel is still needlessly wasted, and that present methods of mechanically firing, as compared with the average hand firing, and burning coal on grates or in retorts increase this waste, but little has been accomplished in regulating combustion so that this loss may be reduced.

Scientific Development of the Steam Locomotive

By JOHN E. MUHLFELD,[1] NEW YORK, N. Y.

Despite the fact that marked progress has been made in the development of the steam locomotive, there still remains considerable opportunity for further improvement, and the general lines along which such improvement should be made form the supporting data of the following paper. The author first briefly outlines the factors involved in the determination of the tractive power of a locomotive. He next discusses such items as boiler feedwater, types of fuel, combustion, heat distribution, steam pressures, superheating, and steam generation and utilization. The acceleration and deceleration of a locomotive are also considered, and the paper is concluded with a discussion of the methods of saving fuel and labor, both of which should produce a higher standard of operation and economy.

STEAM railroads, to be successful, must, through executive foresight and engineering progressiveness, respect the same law of additions and betterments that applies to other profitable industries and which demands continuous modernization of plant and equipment in order to effectively and economically meet the necessity for greater production and speed by means and methods that will result in the least possible artificial age being capitalized in the improvements when installed.

Marked progress has been made in the development of the steam locomotive as the result of superior engineering ability, and the results have in many respects been exceedingly effective. This progress, however, has been confined largely to an increase in size, weight, evaporation capacity and hauling power, and while the general use of superheaters and firebox baffle walls during the past ten years has substantially assisted in improving sustained boiler capacity and increasing thermal efficiency as well as in keeping the steam locomotive in advance of the electric locomotive, the opportunity for further improvement in thermal and machine efficiency and to reduce smoke, cinders, gases and noise is untold.

The desiderata in a steam locomotive may be summed up as: a reasonable first cost; maximum capacity for the service within roadway weight, curvature and clearance requirements; ability to handle the heaviest gross tonnage practicable at the highest permissible speed; positive control of mechanical operation; economy as regards fuel and water consumption and repairs; minimum manual labor for road and terminal handling; construction of the least number of parts, and capacity to perform continuous mileage without failure.

Modern types of steam locomotives fulfill quite satisfactorily all of these requirements with the exception of wastefulness in fuel, water and steam consumption as may be gathered from the fact that the thermal efficiencies now obtained are only from 50 to 65 per cent at the boiler, from 60 to 75 per cent for combined boiler and superheater, and from 4 to 6 per cent at the drawbar. These as compared with thermal efficiencies of from 3 to 5 per cent at the drawbar of an electric locomotive, 18 to 19 per cent at the switchboard of a modern steam-electric central power station, 25 to 30 per cent for internal combustion engines, and 40 to 45 per cent as claimed for the full range of from one-quarter to full load for combination internal-combustion and steam motors.

The increase in the first cost and in the cost for labor, fuel, material and supplies for operation and maintenance of the steam locomotive has been most marked during the past ten years, particularly since the war. It is now being operated and maintained by highly paid enginemen and mechanics, with high-priced materials and supplies, and the machine and its performance must be brought up to a more respectable basis of engineering efficiency if it is to be perpetuated.

The supporting data of this paper, which apply to the United States, present the reasons why the general improvement of the steam locomotive should embrace the following changes which, it may be opportune to here state, are now being embodied in the design, specification and construction of a new type of locomotive, the first of which it is planned to have in regular service in 1920 on a prominent and progressive Eastern railroad:

a Steam at a pressure of about 350 lb. to be employed, superheated to about 300 deg. fahr.
b Improved boiler, furnace and front-end design and appliances
c Greater percentage of adhesive to total weight, and a lower factor of adhesion
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The combustion rate generally follows the increase in draft until about 100 lb. of bituminous and about 50 lb. of anthracite coal are burned per square foot of grate area. After this the additional coal supplied is not effectively consumed, due to the difficulty in supplying sufficient air, equally distributed, through the grates and fuel bed to oxidize the fixed carbon and volatile matter in process of combustion without a large excess of air, such as obtains when forcing takes place, and it becomes necessary to open the fire door so that combustion can be completed by the admission of air above the fuel bed.

The greatest loss in heat is that due to the heat carried off in the stack gases, sparks and cinders, which usually results in a smoke-box temperature of from 500 to 750 deg. fahr. for the best practice. Adding to this the heat losses due to combustible in ash, vapors of combustion, carbon monoxide and otherwise, leaves an average of from 25 to 40 per cent of the heat in the fuel as fired unabsorbed by the boiler and superheater.

With the best hand firing, when using dry bituminous coal averaging 14,400 B.t.u. and 60 per cent fixed carbon, 32 per cent volatile and 8 per cent ash, the fuel rates in Table 2 will usually obtain:

TABLE 2 CONSUMPTION OF DRY BITUMINOUS COAL BY LOCOMOTIVE WITH BEST HAND FIRING

Total indicated horsepower of locomotive	Dry coal per I.hp-hr.
500	2.8
750	2.7
1,000	2.6
1,250	2.5
1,500	2.6
1,750	2.8
2,000	3.0
2,250	3.2
2,500	3.4

As compared with hand firing, stoker firing will result in an increase of from 10 to 25 per cent in the fuel fired, while if the same coal be pulverized and burned in suspension there will be a decrease of from 15 to 25 per cent in the amount of fuel fired.

As the locomotive firebox, which in the best practice represents only from 7 to 10 per cent of the total boiler evaporating surface, must generate all and absorb from 30 to 40 per cent of the heat energy that is converted into drawbar horsepower, the fuel effectively consumed, not fired, is the measure of work done. Therefore the largest permissible combination of firebox and combustion-chamber volume, heating surface and grate area should be provided and equipped with an arrangement of firebrick baffle walls placed on water-circulating supports in a manner to produce long flame travel, high firebox temperature and the maximum radiant heat for absorption by the surrounding water.

With the usual limitations in firebox volume, too much importance cannot be placed on the arrangement of heat-absorbing and radiating walls for the purpose of flame and radiant-heat propagation. Carefully conducted tests have shown that the best results are obtained from solid firebrick baffle walls, and that the unburned gas, coal-dust, spark, cinder and smoke losses are reduced with an increase in their length and gas-passage arrangement.

The greatest difficulty in controlling combustion occurs at high horsepowers and long cut-offs, and where grates are used, and for the best results the air openings should be equal to about 50 per cent and those in the ashpans to about 15 per cent of the total grate area, so that firebox temperatures of from 2000 to 2500 deg. fahr. can be obtained and the unburned solid fuel, carbon monoxide and excess air over the fuel bed reduced to a minimum.

As with dry pulverized coal of 12,430 B.t.u. value, an average boiler efficiency of 69.2 per cent at 1080 boiler hp., and an average combined boiler and superheater efficiency of 78.1 per cent at 1220 boiler hp., with an equivalent evaporation averaging 42,100 lb. of water per hour from and at 212 deg. fahr., has already been obtained on a Mikado simple-cylinder type of locomotive hauling fast freight trains over a 113-mile division, the possibilities for reducing the steam-locomotive fuel consumption are practically unlimited, and much remains to be done in this direction by good hand firing, through a combination of the fireman's eyes, brain and brawn, provided the thermal efficiency of the modern locomotive at the drawbar is brought up to where it can and should be.

Boiler-Water Circulation

In designing a boiler it is extremely desirable to secure the most rapid circulation practicable, as with high combustion rates and temperatures and the abnormal state and behavior of the water film in contact with the heating surfaces, the load on the firebox sheets is very intense, the conduction rate averaging from 75,000 to 100,000 B.t.u. per sq. ft. of evaporating surface per hour.

Therefore, in order to avoid resistance to heat transfer, with resultant overheating of metal and reduced efficiency, a relatively high velocity of circulation and at least a rate of 125 ft. per min. in the most sluggish locality is very essential.

The average locomotive boiler does not present ideal water-circulation possibilities, but the enlarging of contracted spaces, increasing of water-leg, flue and tube clearances, and provision of suitable outlets from choked water pockets will not only reduce the resistance to the "slip" of the steam bubbles through the water, but will enable the accelerated action of the former to increase the velocity of the latter and thereby improve general circulation and heat transfer results.

Heat Radiation, Convection, and Conduction

Heat Radiation. In a locomotive boiler the efficiency of combustion heat transfer through the firebox plates and boiler flues and tubes is from 20 to 25 per cent greater as applying to those heating surfaces directly affected when subjected to the radiant effect of the incandescent combustible and non-combustible particles which have passed through the minimum distance, than the heat-transfer efficiency when convection only is available. For example, when coal is hand or stoker fired and burned on grates or in retorts the radiant heat is at a minimum and applies only to the heat-absorbing surfaces adjacent to the fire bed, while the heat of convection is at a maximum; whereas when the coal is burned in pulverized form in suspension this condition is reversed. The locomotive boiler of the future will undoubtedly depend more largely on radiant heat.

With respect to the loss of power through radiation to the atmosphere, there is sufficient justification for completely and properly lagging the boiler, firebox, cylinders and heads, steam chests and all other radiating surfaces, as well as for polishing certain machinery parts, in order to reduce the dissipation of heat that now takes place through these parts from the existing steam pressures and superheat.

Heat Convection. In the present locomotive boiler by far the greatest proportion of the heat is imparted to the evaporating and superheater surfaces by convection.

To secure the fullest benefit from heat convection the combustion volumes and gas areas must be so coördinated as to establish a "velocity pressure" or " frictional" action between the gases and the heat-absorbing plates and tubes in order to increase the rate of heat transmission. Likewise must the boiler circulation be expedited in order to quickly disengage and release the steam bubbles from the water side of the same plates and tubes in the final heat transfer.

The possibilities for improving heat transmission by convection in the locomotive boiler, with its high water rate, i.e., a boiler horsepower for an average of less than 2 sq. ft. of total evaporating surface, fully justifies additional study.

Heat Conduction. The transmission of heat from one body of high temperature to another body of low temperature by contact, or from one part of a body to another part, is termed external and internal conduction, respectively.

Any increase in the rate of external conductivity, considering the present kinds and thicknesses of firebox, flue and tube materials as practically fixed, must be through an increase in the rate of flow of the heated gases, and this in turn means the expenditure of a greater amount of energy to pull these gases through the boiler.

While there is no difficulty in now obtaining a boiler horsepower from each 1½ to 2 sq. ft. of total evaporating surface, whatever

further improvement can be made in this direction will provide just that much more margin of boiler over cylinder horsepower requirements and produce a corresponding gain in efficiency.

STEAM GENERATION

In present locomotive operation the quality of the steam, i.e., the percentage of vapor in a mixture of vapor and water, is one of the most important and least-referred-to factors in road and laboratory test reports, particularly as the average modern locomotive boiler is notorious for delivering saturated steam to the superheater or to the steam pipes with a high percentage of entrained moisture.

Road tests recently conducted on modern Mikado types of locomotives showed an average quality of from 94.7 to 96.3 per cent for the saturated steam as delivered to the superheater, indicating from 5.3 to 4.7 per cent of moisture, which is valueless so far as its power for doing work is concerned, but which greatly increases the work to be performed by the superheater by throwing upon it work which should properly be done in the boiler.

The delivery of dry saturated steam from the boiler is an item that has been given but little consideration in steam-locomotive practice, the principal idea having been to produce evaporating capacity and depend upon the superheater to perform auxiliary boiler functions. Many changes can and should be made to improve this condition.

STEAM-PRESSURE INCREASE

One of the greatest and simplest improvements to be made in the steam locomotive can be effected by an increase in the boiler pressure in combination with greater quantity and better quality of saturated-steam production, higher and more uniform superheat, and compounding.

The writer advocated a steam pressure of 250 lb. in 1902 when with the Canadian Government Railways, and inaugurated the use of 235 lb. boiler pressure in combination with 21-ft. boiler tubes in 1903 in the Baltimore and Ohio Railroad Mallet articulated compound locomotive No. 2400, with excellent results from both an operating and maintenance standpoint. This at a time when the general tendency was to reduce rather than to increase locomotive steam pressures from an established practice of about 200 lb.

During recent years stationary-boiler engineers have not only determined upon their efficiency, but have inaugurated the use of relatively high steam pressures, and with the urgent necessity for keeping the cylinders as small in diameter and the reciprocating and revolving parts as light as practicable, there would appear to be no good reason for not now utilizing saturated steam of 350 lb. pressure, which, in combination with 300 deg. fahr. of superheat should provide, in addition to the many other advantages, a much greater opportunity for economy in power generation.

STEAM SUPERHEATING

The use of superheated steam has done more to increase sustained hauling power, reduce fuel and water consumption and increase thermal efficiency than any of the other means and methods that have been generally adopted on the steam locomotive since its introduction, either singly or in combination.

With the average superheat now used, from 175 to 250 deg. fahr., the drawbar pull at a speed of 20 miles per hour is increased about 15 per cent, and at 50 miles per hour about 40 per cent, and due to the combination of superheat, larger diameter of cylinders and reduced cylinder back pressure—resulting from the use of superheated steam—it is possible to increase train tonnage about 30 per cent at speeds of about 30 miles per hour.

In the best existing steam-locomotive practice the superheat generally increases with the cut-off up to 50 per cent cut-off, beyond which there is usually a falling off in the superheat. Furthermore, with short cut-off a fair water rate, i.e., about 19 lb. per i.hp., can be maintained, but if the cut-off at the same speed is increased to over 50 per cent the superheat must be increased to about 300 deg. fahr. in order to maintain the same water rate, or otherwise, for example, at 67 per cent cut-off, the steam consumption will increase to 21 lb. or more per i.hp. This for the reason that as the amount of superheat is increased the range of temperature in the cylinder during the stroke of the piston is decreased until with sufficient superheat the changes in temperature cease entirely.

While the increased superheat results in a greater number of B.t.u. being exhausted from the cylinder, any such loss of a marked degree is more than offset by the smaller amount of heat exhausted per stroke, due to the fewer B.t.u. admitted to the cylinder per stroke at a given cut-off.

The use of highly superheated steam results in a saving of about 35 per cent of the total water evaporation per unit of power and in from 10 to 45 per cent saving in fuel when using steam, depending upon the power output.

Existing fire-tube superheaters produce the maximum superheat only when the locomotive is forced to its boiler capacity, whereas the maximum economy is more desirable when the locomotive is working under average conditions at economical cut-offs and when the superheater should give as nearly as possible a uniform degree of high superheat under all conditions of working, regardless of the boiler evaporation. For example, if the degree of superheat obtainable at speeds of 50 miles per hour with 50 per cent cut-off could be obtained at 25 per cent cut-off, a water rate of considerably less than 15 lb. could be obtained as compared with existing rates of about 19 lb. Therefore, as the present limitation in the hauling power of the modern superheated-steam locomotive is the capacity of the boiler to produce continuously sufficient dry saturated steam of high pressure and of the superheater to maintain a uniform high degree of superheat, the possibility of improving it by means of average higher boiler pressures and superheat temperatures and better utilization of fuel, steam and waste heat, in combination with radical changes in the design and arrangement of the boiler and superheater equipment and in the saturated- and superheated-steam connections, offers one of the greatest opportunities to increase efficiency and economy. This applies particularly to the larger locomotives, many of which consume more fuel and water and do less work than the smaller locomotives of the same general design and equipment.

While the superheater has generally been considered as a part of the boiler, particularly as regards its evaporation of entrained moisture in the saturated steam, it has no relation whatsoever thereto in so far as its individual functioning is concerned, and the more that the saturated-steam-conducting and superheated-steam-delivering conduits, as well as the superheater equipment in itself, can be divorced from the boiler and front-end connections and their proper functions, without introducing separately fired apparatus, the better will be the general results from the standpoint of efficiency, maintenance, operation and economy of the locomotive as a whole.

The steam temperature should be uniform for the variable speeds and capacities of operation. At the present time high temperatures obtain only at high speeds and capacities. A minimum temperature of 650 deg. fahr. quickly after starting, and of 700 deg. at maximum power and speed, would be much more effective and economical.

STEAM DISTRIBUTION AND UTILIZATION

Modern types of locomotives have developed at low speeds 3000 i.hp. and at high speeds 3200 i.hp., and comparative average water rates through the complete range of the effective capacity of the locomotive, with piston speeds of from 600 to 1000 ft. per min., have been obtained as shown in Table 3.

TABLE 3 COMPARATIVE WATER RATES OF LOCOMOTIVES WHEN USING SATURATED AND SUPERHEATED STEAM

Cylinders	Steam	Water rate per i.hp-hr., lb.
Single-expansion	Superheated	16 to 20
Single-expansion	Saturated	24 to 29
Double-expansion	Superheated	15 to 18
Double-expansion	Saturated	19 to 22

At piston speeds of less than 600 ft. per min. the water rate of the double-expansion saturated-steam locomotive will approximate that of the single-expansion superheated-steam locomotive.

Compounding. With the exception of the Mallet articulated type of compounding, the multiple-expansion system of steam utilization, which has been so successful in marine and stationary practice, has not made the progress in this country that it has in Europe.

The failure of various types of cross, four-cylinder, four-cylinder balanced and tandem double-expansion locomotives, introduced from 25 to 15 years ago, to produce the predicted economy was due largely to factors of indifferent design, low boiler pressure, excessive condensation, lack of proper maintenance and operation, cheap fuel and road failures. Clearance limitations also restricted the size and arrangement of the low-pressure cylinders, while at the same time the single-expansion cylinder superheated-steam locomotives gave opportunity for greater hauling capacity and economy.

There is no doubt but that a properly designed superheated cross-compound locomotive embodies many advantageous features, such as greater starting and hauling capacity per unit of weight, less evaporating surface per indicated horsepower, reduced fuel and water consumption and less boiler repairs, and that it will return to favor for freight service in combination with higher boiler pressures and superheat, due to the necessity for greater drawbar pull and horsepower and for utilizing all superheat before its final exhaust.

Valve-Motion Gear. The Stephenson valve gear, through its variable lead for different points of cut-off, gives one of the best and most flexible steam distributions for locomotives. However, its undesirable and inaccessible location between frames and driving wheels and heavy revolving and suspended reciprocating wearing parts caused the writer, in 1903, to introduce the Walschaerts valve gear, a Belgian invention, in connection with the design of the Baltimore and Ohio Railroad Mallet articulated compound No. 2400.

The Walschaerts, as well as other outside valve gears now generally used, has the disadvantages of a constant lead and of being affected by the vertical displacement of the axle. By eliminating these disadvantages, however, and adding certain improvements for the purpose of increasing the ratio of expansion and shortening the ratio of compression, the tractive effort can be increased at lease 10 per cent at all points of cut-off and the fuel consumption reduced 5 per cent through ability to develop the same drawbar pull with a shorter cut-off. Such a change will add greatly to the efficiency of the steam locomotive, particularly when it is recalled that the average inside or outside valve gear slightly out of adjustment represents considerable loss in hauling power and in fuel economy. Tests made show that valves out of adjustment are responsible for from 8 to 21 per cent increase in fuel consumption per ton-mile as compared with valves properly set.

Where compound cylinders are used a steam-expansion regulator should be incorporated with the motion gear to effect the automatic independent adjustment of the cut-off for each of the high- and low-pressure cylinders for the purpose of obtaining certain cylinder ratios and at the same time bring the cut-offs in harmony at the center of the quadrant. In this way a compound locomotive of the Mallet articulated type can be made to develop at least 55 per cent of its rated tractive power at a speed of from 8 to 10 miles per hour, when operating at 25 miles per hour, and there will be a gain in tractive power of about 15 per cent at 25, and of about 10 per cent at 30 miles per hour.

Cylinder Clearance. The inauguration of the use of the inside-admission piston valve and of superheated steam has brought with it the wasteful effects of larger cylinder clearance, due principally to the use of a valve of too large diameter and an indifferent design of valve chest and ports in combination with the cylinder castings.

The use of smaller-diameter piston valves located close to the cylinder and connected with properly designed expanding steam ports will, in combination with improved material and workmanship, correct these generally existing deficiencies.

Cylinder Back Pressure. About 75 per cent of the cylinder back pressure is due to the use of the exhaust steam to produce draft for combustion, evaporation and superheat.

Much remains to be done in the way of enlarging exhaust-steam openings from the cylinder to the atmosphere and in reducing existing sharp turns, cramped passages and obstructions to the free passage of steam through them; and also in the development of an exhaust stand and nozzle that will combine the advantages of the single and double types.

Valves and Cylinders. Various tests on and many years' experience with inside-admission piston valves have demonstrated through the better use of steam and the resulting reduction of jerking, pulling and stresses on valve stem and gear, unbalanced pressure, frictional contact, valve and bushing wear, leakage, and lubrication, the practical advantages of a minimum diameter and weight of valve with the circumference no greater than the length of a slide-valve port and with every inch of bushing port made effective and designed in conformity with the well-known principles governing the flow of gases so as to eliminate eddies and baffling in the steam flow between valve and cylinder.

Piston Speeds. Frequent errors have been made in not properly proportioning the driver-wheel diameter and stroke of the piston. Slow speed and high ratios of expansion are factors particularly favorable to superheated steam and piston speeds of from 700 to 1000 ft. per min. will insure the best results.

Waste-Heat Distribution and Utilization

As a reasonable estimate would show that 40 per cent of the heat in the steam and in the products of combustion is exhausted from the stack, any considerable part of this heat that can be reclaimed for preheating boiler feedwater will add greatly to the overall efficiency of the locomotive and to the saving in fuel.

The principal means through which to accomplish this saving, in a practical way, are exhaust-steam heaters and flue-gas economizers, both of which can be readily adapted to a modern steam locomotive.

Exhaust-Steam Heaters. From actual service tests of closed types of heaters made on modern superheated-steam locomotives, using a portion of the main-engine exhaust steam only, it has been found that a feedwater temperature approximating 240 deg. fahr., or within 15 deg. of the exhaust-steam temperature, can be obtained without interfering with the draft required for maximum steam and superheat generation.

Flue-Gas Economizers. An economizer will heat the feedwater to a higher temperature than an exhaust-steam heater and will recover most of the waste heat resulting from high steam pressure and high superheat, as it is able to recover low-temperature heat that has escaped from the boiler evaporating or superheater surfaces because the average temperature of the feedwater within the economizer — which should, if practicable, be brought up to the boiler evaporating temperature — is much lower than the temperature of the water in the boiler.

As locomotive-smokebox superheaters, now obsolete, have demonstrated that 50 deg. of superheat may be obtained from flue gases at 600 deg. fahr., there should be no difficulty in devising a locomotive economizer that will produce very effective results in combination with high boiler pressures, superheat and draft, without baffling the boiler draft and evaporating capacity. In fact, with an average boiler efficiency of 60 per cent and an economizer efficiency of 50 per cent the possibility of recovering from 25 to 50 per cent of the stack-gas losses and increasing the thermal efficiency of the entire unit, is within the limits of possibility.

Friction and Resistance

Friction. The only form of useful friction to which the steam locomotive is subject is that which occurs between the driving wheels and rails for adhesive purposes. All other friction due to oscillation, concussion, rolling, wheel flanges and treads, journals, cylinders, valves, valve gear, crossheads, center and side bearings, coupled side play and the like, absorbs a considerable percentage of the power developed by the steam.

During the past ten years the increased rigid wheelbase and axle loads, greater lateral rigidity, larger cylinders, valves and revolving and sliding bearings, substitution of grease for oil lubrication, and greater number of frictional parts have tended to increase the machine friction and consequently the horsepower, drawbar pull, and steam and fuel losses, all of which are factors that should receive proper consideration in new designs.

Resistance. Other than the resistances resulting from machine friction, the locomotive is subject to those due to grades, curves, weather, wind and head air, which latter is more particularly affected by the general design.

While the complicated design of a steam locomotive, particularly as regards the application of its accessories, makes the use of relatively smooth outside surfaces generally impracticable, still much has been done along this line on some of the European railroads that can be adopted by us to good advantage.

Acceleration

In a steam locomotive the effects of inertia are distributed throughout the machine, due to the variable speed and action of the locomotive as a whole as well as of its reciprocating and revolving parts, and in order to indicate the force necessary to overcome this inertia and produce a particular speed in a given time, per ton of 2000 lb. of engine and tender, exclusive of the resistance due to grade, curvature and friction, the data in Table 4 may be of interest.

TABLE 4 FORCE REQUIRED IN LOCOMOTIVE ACCELERATION

From rest to given speed in miles per hour	Time allowed in seconds	Average force required per ton of engine and tender to overcome inertia only, lb.
10	60	16
20	60	32
30	60	48
40	60	64
50	60	80
60	60	96
70	60	112
80	60	128

As the train resistance increases and the drawbar pull of the locomotive decreases due to speed, acceleration rapidly becomes a diminishing quantity. Therefore in order to expedite train movement locomotives should be designed and adjusted so as to permit of the highest possible rate of acceleration in the shortest distance after starting, in order that the maximum desired running speeds can be reached in the minimum of time during which the greatest evaporating capacity of the boiler is available.

Deceleration

The deceleration or retardation of a steam locomotive is now universally produced by brake shoes brought against the treads of the driving and truck wheels by various means, the ideal method being where the maximum stopping effort is at all times under the positive control of the engineer. While the reversing of the engine with or without the use of steam effects varied degrees of stopping power without the use of brake shoes, this method is generally too slow and cumbersome for present-day requirements.

With the best existing air-brake practice a Pacific-type passenger locomotive weighing about 90 tons on 80-in.-diameter driving wheels and from 200 to 220 tons total for engine and tender in working order, will, when braked to from 110 to 90 per cent of the total weight, make stops on straight level track under good rail conditions, from a speed of 60 miles per hour, in distances of from 1200 to 1600 ft., and in from 25 to 30 sec., respectively, whereas from a speed of 30 miles per hour, under otherwise identical conditions, stops can be made in distances of from 275 to 325 ft., in from 12 to 13 sec., respectively. When braked at 150 per cent the stopping distance from a speed of 60 miles per hour can be reduced to about 1000 ft.

Deceleration is as much a factor in expediting train movement as acceleration, particularly with long and heavy trains and grades, and improved brake-shoe design, material, flexibility and bearing area in combination with clasp types of brakes for all wheels would do much toward providing greater stopping control over large and high-speed steam locomotives and thereby avoid the necessity for resorting to the use of the engine-cylinder back pressure to produce adequate braking power without liability for skidding and flattening the driving wheels.

Lubrication

It is false economy to restrict the quantity of lubricants used or to employ inferior lubricants to the extent that results in excessive friction, wear and tear, and any saving thus effected is many times over expended in delays, repairs, and fuel. At the same time probably no locomotive supplies are handled more wastefully or ignorantly than oil and grease, due to the lubricant not being applied or used in the proper manner.

Difficulty of access to the various bearings to be lubricated and the necessity for frequent hand oiling have no doubt contributed to lubrication waste and trouble, but during the past 15 years the substitution of grease for oil on many bearings, the use of larger driving wheels and lower piston speeds, and greater accessibility to certain parts as obtains from the use of outside instead of inside valve gears and journals, have brought about a substantial improvement.

Special Appliances

The steam locomotive, other than the boiler, engine, frame, running gear and tender proper, is largely an assembly of special appliances for firing, combustion, superheating, steam distribution and utilization, feedwater delivery, lubrication, insulation, heating, lighting, safety, and labor saving, and of devices such as trucks, axles, wheels, tires, springs, bearings, brakes, draft gear and boiler fittings.

These appliances and devices are the result of highly specialized research, designing and experimenting by the railway supply and equipment companies, who in turn are largely responsible for the development of the steam locomotive which has occurred during the past fifteen years.

With the cost for locomotive fuel and repairs averaging over 75 cents per mile run, or five times what it was ten years ago, the cost for the essential design, material, construction and equipment of the locomotive must now be placed on an engineering rather than on a purchasing price basis in conformity with other high-class machinery if more efficient and economical operation and maintenance results are to be obtained.

Power for Accessories

The steam locomotive must not only produce superheated steam for the development of drawbar pull, but also supply saturated steam to various accessories of its own and for train operation. For example, a modern passenger locomotive is required to supply power to operate locomotive and train air brakes and signals as well as train lighting, heating and ventilating equipment, and hot- and cold-water systems, and in addition it must supply steam or compressed air for the operation of a multitude of devices. As high as 20 per cent of the fuel as fired for an average divisional run may be used for these accessories.

Not only has the use of compressed air been found to be most expensive for the working of these accessories, but the reserve supply for train braking has been frequently drawn upon for their operation. As power reverse gears, fire doors, water scoops, coal pushers, ashpan doors and like devices can be equipped for steam operation, such substitution offers possibilities for less drain on the boiler and much-needed economy in the cost for this auxiliary power production. Moreover, as all of this power for accessories is produced by saturated steam, some means for substituting the use of superheated steam for those purposes where it is more suitable and economical should be given due consideration.

Octaval Notation in Shop Measurements

By ALFRED WATKINS, HEREFORD,[1] ENGLAND

This paper is an argument for the adoption of a system for measuring binary inch fractions. At present there are two systems; the first divides the unit into halves, quarters, eighths, etc., and the second makes use of a decimal notation. The author proposes to replace these by an octaval notation in which eight is to be used as the radix. After explaining the method of constructing such a notation, the author discusses its application. A description of various types of measuring instruments with octaval notation shows its many advantages. The following instruments are discussed in detail: octaval rule, simple vernier calipers, double vernier calipers, single-screw micrometer, and two-screw micrometer. The author states that it is not his intention to propose the substitution of octavals for decimals in all branches of engineering, but he does advocate their use to denote the British binary inch fractions in the workshop and on workshop measuring instruments.

A RECENT investigation into the usage of coinage, weights and measures of all kinds, summed up in the author's pamphlet, Must We Trade in Tenths, showed two distinct and clashing tendencies. The first, which is prevalent in all branches of commerce and craft, is to divide a unit into halves, quarters, eighths, etc., down to sixty-fourths. The second tendency is on the part of the man who has more to do with computation than actual exchange or craft. He, finding a decimal notation all cut and dried and usable with easy facility, is thoroughly impatient with any other method, and wants his to be universal and compulsory. To this class belongs the counting-house man, the schoolmaster and the scientist, who have never entered into the unexplored science of commerce and handicraft. And as we all, with a slight exception in dozens, count upward from unity in a ten grouping, many of us are apt to decide that the ten grouping is also an inevitable division of the unit downward. But this ignores the general fact that no market man or craftsman does divide a unit into tenths until forced by the counting house into doing so. The figure ten only halves once into a whole number, and after that each halving adds an additional decimal place. The ten grouping is not the only scale of notation and such textbooks as Hall & King's Elementary Algebra point out those with a basis or radix of 6, 8, 12, 16, or any other numbers and give rules for the conversion of one notation to another. It is exceedingly unlikely that we shall disturb the ten grouping for our counting from unity upward. But there is not the slightest difficulty in expressing parts of a unit in modern fractions of some other radix than 10.

Unfortunately there is no notation which fits perfectly with all fractions used in commerce or craft. The three groups of fractions most used are 3ds, 6ths and 12ths; 5ths and 10ths; and the binary group, 4ths, 8ths, down to 64ths. The last group is undoubtedly used more than all the others put together, especially in the mechanical division of a unit of length, and a numeration with a binary radix is best. As a radix of 16 would necessitate the selection of six new numbers, 8 is the scale of notation to select, and it fits the engineer's binary inch fractions to perfection.

An octaval fraction is distinguished from a decimal fraction by a special mark, the small circle or "pip," originated by the author, and placed in the same position as the decimal point. Octaval fractions can be added, multiplied, etc., with much the same facility as decimals and far easier than vulgar fractions, as for example:

Vulgar	Octaval
$\frac{1}{2}+\frac{33}{32}=\frac{32}{64}+\frac{33}{64}=\frac{65}{64}=1\frac{1}{64}$	$_{\circ}4$ + $_{\circ}41$ = $1_{\circ}41$

Note that as 8 is the radix, it becomes 10 in all octaval arithmetic.

[1] The Watkins Meter Company.

For presentation at the Annual Meeting, New York, December 1919, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS. The paper is here printed in abstract form and advance copies of the complete paper may be obtained gratis upon application. All papers are subject to revision.

In the structure of octavals, just as 0.2345 in decimals

$$=\frac{2}{10}+\frac{3}{10^2}+\frac{4}{10^3}+\frac{5}{10^4}$$

$$=\frac{2}{10}+\frac{3}{100}+\frac{4}{1000}+\frac{5}{10{,}000}$$

so, $_{\circ}2345$ in octavals $=\frac{2}{8}+\frac{3}{8^2}+\frac{4}{8^3}+\frac{5}{8^4}$

$$=\frac{2}{8}+\frac{3}{64}+\frac{4}{512}+\frac{5}{4096}$$

APPLICATION TO INCH FRACTIONS

The foregoing explanation leads up to the subject of this paper, which is the practical application of octaval notation to the construction of micrometers, calipers and measuring rules, and the great ease and facility it imparts to the measurement of the allowances and limits so much used in precision work. Our present crude blend of decimal allowances with standard binary fractions is complex and illogical, and it would seem that as a "limit" table is based on the square root of the diameter of the part, it can be more accurately and simply compiled in octavals than in decimals. The structure of an octaval fraction is much on the lines of a mechanic's mental conception of the fraction. Thus $_{\circ}42$ ($\frac{4}{8}+\frac{2}{64}$) for the fraction usually called $\frac{17}{32}$ is obviously half an inch plus a thirty-second. It should be also noted that the octaval figures are continuous, so that adjacent fractions as $\frac{1}{2}$ and $\frac{33}{64}$, so inconveniently expressed now, are in octavals $_{\circ}4$ and $_{\circ}41$, obviously adjacent. With an octaval radix the counting omits 8 and 9, and goes directly from $_{\circ}7$ to $_{\circ}1$, from $_{\circ}17$ to $_{\circ}2$ and so on until $_{\circ}77$ is reached, when the next value upwards is 1 0 or unity. The

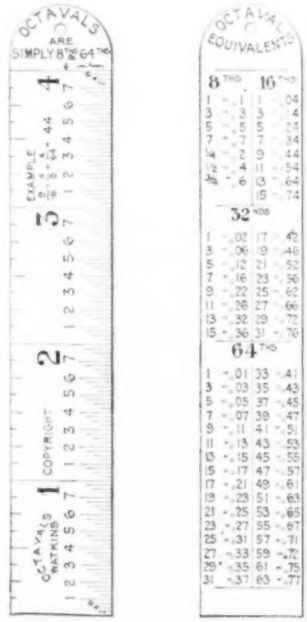

FIG. 1 OCTAVAL RULE

octaves of the eighties and nineties are omitted as well as the single figures 8 and 9.

MEASURING INSTRUMENTS WITH OCTAVAL NOTATION

It will be noticed that in the instruments illustrated (Figs. 1-4) all, or almost all, the divisions can be marked with figures indicating their value, and that, except in the case of the rule, there are no very fine divisions to try the eyes. It should also be noted that in each case there is a separate scale for each place in the fraction, each figure of it being read separately, so that no addition is necessary to get the results.

Octaval Rule. The octaval rule, Fig. 1, shows that all the eighths are figured, and the figures form the first place in the octaval fraction. The writer has devised an original way of indicating the subdivisions of the eighths (the sixty-fourths) in staircase fashion which enables the alternate even numbers to be marked, and these numbers constitute the second place in the octaval fraction. This method of a different length of line for 2, 4 and 6 allows the value of the indicated division to be known, even if it is not uncovered by the thimble or sliding bar of a measuring instrument. It is applicable to decimal divisions and to ordinary and slide rules.

Simple Vernier Calipers. The simple vernier calipers shown in Fig. 2 measures down to 64ths, and yet the divisions are scarcely finer than eighths. The vernier method is used, and every division is figured. The index line points to the first figure of the fraction, or beyond it, short of the next division, and the vernier line which coincides with any upper division is marked with the second figure of the fraction. A partial dislike to the vernier method is probably due to their usual association with fine eye-straining divisions.

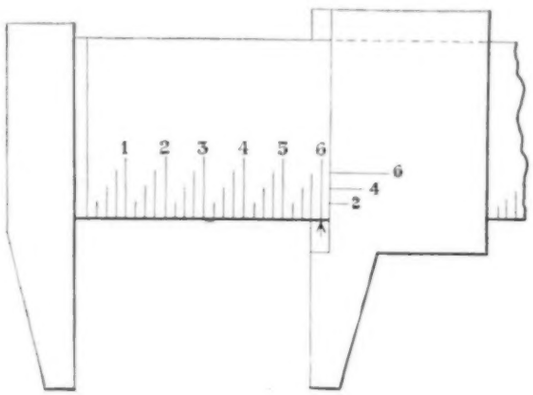

FIG. 2 SIMPLE VERNIER CALIPERS

Double Vernier Calipers. A flat model of the double vernier calipers is illustrated in Fig. 3 in order to show its action more plainly, although it is quite probable that a model with a circular stock will be the commercially useful one. The standard fraction is set, in two places of octavals, exactly as in the instrument already described. A fine movement for the 3d and 4th octaval places is frictioned on the coarser movements. It is a double wedge with a taper of 1 in 32, and a movement of 1/16 in. on this cross slide moves the calipers $5\frac{1}{2}$ or .001 in the third place of octavals. The 4th octaval place is indicated by a vernier scale. In this, as in the next instrument, the 1st, 2d, 3d and 4th scales are lettered *A*, *B*, *C* and *D*. The advantage to which reference has been made of devoting two scales to the main fraction and the two others to the allowance, shows up very strongly in this instrument, for there is a separate plus and minus scale for the allowance. The mechanic has therefore only to set one part of the calipers for his main fraction and the other part for his allowance, either plus or minus, and has no pencil or mental calculation to make. No decimal instrument can do this unless the standard main fractions adopted are tenths or hundredths. It will be noticed that the construction remedies a fault in previous beam calipers which had the pull of the fine adjustment on one side of the main axis of the instrument. When used to caliper the exact size of an unknown dimension, the jaws are adjusted to the size, and a front clamping screw, not shown, is tightened on the beam, the rear screw being left loose. The fine adjustment is then worked so that a vernier line on the scale *B* coincides with an upper division. The *C* and *D* scales then indicate the variation from the standard fraction. It should be noted that this construction makes the reading of the second place of the fraction different from previous instruments. With this one it is always set exactly for the precise standard fraction, and the fine adjustment does not alter this setting, but indicates how much more, or less, than the standard the dimension is, or is intended to be.

Two-Screw Micrometer. The two-screw micrometer shown in Fig. 4 is the result of the author's conviction that the separation of the scale for the main fraction from that of the allowance, rendered possible by their being expressed by different places in octavals, is a great practical convenience. In this instrument the standard fraction is measured by the usual screw on the right hand. It is of 8 pitch, probably 4 threads. It indicates the first octaval place,

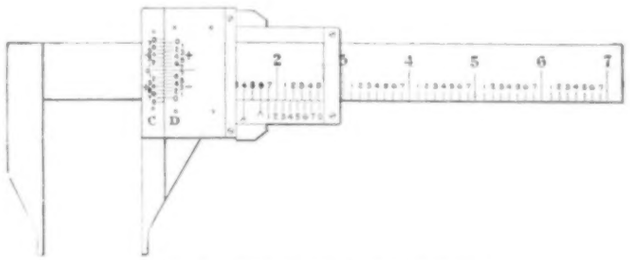

FIG. 3 DOUBLE VERNIER CALIPERS

eighths on the index line, which also points to the 8 divisions on the thimble for the second octaval place. For measurement of the main fractions this is all that is required. The end usually occupied by a fixed anvil is fitted with a measuring screw for the allowances, 3d and 4th octaval places, which is kept at zero until required. This is a 32-pitch screw, it has a range of one revolution only, and its thimble has a double scale starting each way from 0 for plus or minus allowances. The 4th octaval place is read by a vernier scale. The workman, therefore, sets his standard fraction on the coarse screw, turns the micrometer round and sets his plus or minus allowance on the fine adjustment, there being no calculation either for him or for the draftsman. As illustrated, the fine adjustment was used left-handed, but it would probably be figured to use it on

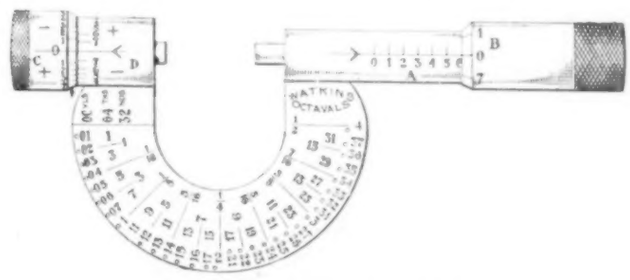

FIG. 4 TWO-SCREW MICROMETER

the right hand, and the position and the use of the vernier would then be exactly those that workmen are familiar with in the present instruments.

To measure an unknown dimension in four places of octavals, the coarse adjustment is first set to the article which is withdrawn, and the screw screwed in to register the nearest (smaller) standard fraction. The final measurement is then made with the fine screw which would probably be fitted with a ratchet, and the instrument would then read for the four places of octavals expressing the dimension. The fine adjustment end can be used alone for measuring fine dimensions less than 1/64 or the coarse-adjustment screw alone for the main fractions.

(*Continued on page 905*)

Thread Forms for Worms and Hobs

By B. F. WATERMAN,[1] PROVIDENCE, R. I.

The use of worm gearing is steadily increasing, and accompanying it, perhaps the cause, is a corresponding increase in efficiency and durability which is the result of a better understanding of both the theoretical and mechanical problems involved. The following paper is a discussion of these and failure to take them into consideration in the past has often led to the discrediting of this form of drive. This paper also suggests methods for bringing about a uniform and satisfactory practice in worm gearing.

IT is only recently that engineers have considered a worm gear in any other light than that of a necessary evil, and this is probably due to the fact that heretofore the finer points of manufacture were not appreciated and were not obtained except in those places where this type of gear had received more than the usual amount of study. The actual manufacture of the worm and gear, however, presents certain mechanical difficulties and inaccuracies

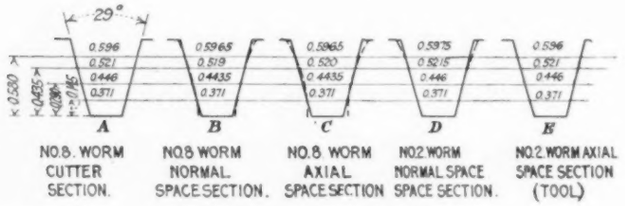

FIG. 1 DOUBLE-THREADED WORM

which are not apparent in any theoretical discussion of the subject. These difficulties appear in making the worms and hobs, especially with multiple threads, in fact it might be said they appear in making worms or hobs whose helix angle is greater than 18 deg., and although no attempt has been made to show these difficulties mathematically enough models have been made to clearly indicate them. These uncertainties are due to the differences in the thread forms produced by the different methods of cutting the worms; first, with an axial tool, the use of which is limited to a rather low helix angle; second, with a normal tool which has no limit for angle; and third, with a rotary cutter.

The most common worm has a single thread. This is usually made with the sides of the threads on the axis forming an included angle of 29 deg., and it can be cut with a lathe tool of 29 deg., the cutting edge of which is set parallel either to the axis or to the normal section. It can also be cut with a rotary cutter of the same included angle in a thread milling machine. In other words, the hob which must be backed off with a tool, set either to the normal or on the axis, can be made either way, and the wheel produced will mesh properly with the worm made in either of the three ways just mentioned.

To demonstrate the difference above mentioned, 13 worms were made to the dimensions given in Tables 1 and 2, which also gives all the necessary working information for producing them. The pitch diameter and axial pitch are the same for all, and this applies equally well to double threads, except that in the case of double threads the difference between the normal and axial sections begins to be noticeable. In the case of worm No. 8, Table 1, which was cut with a straight-sided milling cutter, it will be noticed that the thread is perceptibly convex. This difference is shown in Fig. 1, where the dimensions of the cutter which cut worm No. 8 is shown at *A* with the dimensions of tools fitted to the normal and axial sections at *B* and *C*. In all the references to the normal or axial sections, it is to be understood that the space section is meant.

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This method of analysis permits a visual inspection of any difference in shape of thread, as the model or dummy worm can be held to the light and the difference readily seen. The figures show in

TABLE 1 DATA FOR WORMS

No. of Worm	No. of Threads	Outside Diam.	Angle of Thread with Axis, deg.-min.	$90° - \alpha = \delta$, deg.-min.	Cutting Tool Used	Included Angle of Tool Used, deg.	Tool Cut on Axis or Normal	Diam. Cutter	Addendum, S	$D + f$	Normal Thickness, t	Lead	Bottom Diam.
1	Sin.	3.50	83-39	6-21	Lathe tool	29 on axis	Axis	Same Tool as No. 2	.3181	.6866	.497	1.00	2.127
2	Dou.	3.50	77-28	12-32	"	"	"	Same Tool as No. 1	.3183	.6866	.488	2.00	2.127
3	Tri.	3.467	71-33	18-27	"	"	"	..	.302	.651	.475	3.00	2.165
4	Five	3.420	60-56	29-4	"	"	"	..	.278	.600	.437	5.00	2.220
5	Five	3.50	60-56	29-4	"	"	"	..	.3183	.6866	.437	5.00	2.127
7	Sin.	3.50	83-39	6-21	Cut.	29	Normal	3½	.3183	.6866	.497	1.00	2.127
8	Dou.	3.50	77-28	12-32	"	"	"	"	.3183	.6866	.488	2.00	2.127
9	Tri.	3.467	71-33	18-27	"	"	"	"	.302	.651	.475	3.00	2.165
10	Five	3.420	60-56	29-4	"	"	"	"	.278	.600	.437	5.00	2.220
11	Five	3.420	60-56	29-4	"	50	"	"	.278	.600	.437	5.00	2.220
12	Sin.	3.500	83-39	6-21	"	29	"	6	.3183	.687	.497	1.00	2.127
13	Five	3.420	60-56	29-4	"	50	"	6	.278	.600	.437	5.00	2.220
14	Five	3.420	60-56	29-4	Hob.	29	"	..	.278	.600	.437	5.00	2.220

ALL DIMENSIONS ARE IN INCHES. WORMS ARE IN EVERY CASE 2.8634 IN. PITCH DIAM. AND 1 IN. AXIAL PITCH

α = Angle of thread with axis
δ = Helix angle
S = Addendum = top of thread to pitch line
t = Thickness of thread at pitch line
$D + f$ = Whole depth of thread

thousandths of an inch what the difference is, the dotted lines showing divergence of the sides of the teeth from the straight line in an exaggerated way.

A tool fitted to the normal of worm No. 2, Table 1, is shown at *D* in Fig. 1, and can be compared to the axial section shown at

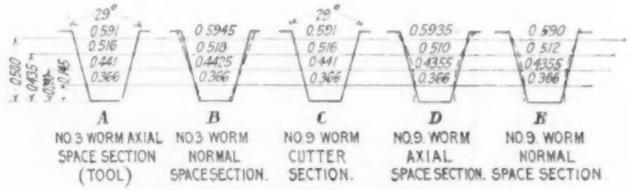

FIG. 2 TRIPLE-THREADED WORM

E. While the difference in shape is noticeable and measurable for a double-threaded worm for all practicable purposes, the statement made about a single-threaded worm holds true for a double-thread. When a triple-threaded worm is considered, the method of cutting becomes of greater importance, since the difference in form between the axial and normal sections (which results from the different methods of cutting) is great enough to require that the hob teeth shape be made exactly like that of the worm. This appears to be a superfluous statement, but it is the exception for a purchaser of a hob to state how he intends to cut the worm, no matter how many threads it has.

Worms No. 3 and No. 9 are triple-threaded, No. 3 being cut with an axial tool in a lathe, and No. 9 with a rotary cutter. The difference in the normal and axial sections of worms No. 3 and No. 9 are shown in Fig. 2. The difficulty just mentioned as to

cutting clearance on the axial lathe tool may also be experienced with a hob that has axial grooves, so that when the angle becomes 18 deg. or greater, it is well to use spiral grooves, as the hob, unless it has ample radial clearance, may drag on one side.

A more extreme case, but now a very common one, is a five-threaded worm where the helix angle is approximately 30 deg. The angle of the thread at the root governs the clearance angle on the tool, and in the case of worm No. 4, the bottom helix angle is 35 deg., 39 min., and in worm No. 5 the helix angle at the bottom is 36 deg., 48 min. The depth of worm No. 4 is based on the normal pitch, while the depth of No. 5 is based on the axial pitch. The shallower tooth eliminates some of the difficulties experienced with these extreme helix angles, and it is good practice to use the normal depth as soon as 18 deg. angle is reached, or when spiral grooves are used in the hob. With a helix angle of 45 deg., which is quite common with axial depth, and 29 deg. thread, either axial

TABLE 2 TOOTH PARTS FOR DIFFERENT WORMS
All dimensions are in inches

No. of Threads	Applies to Worms Nos.	Thread Angle, $90-\alpha=\delta$ deg., min.	Top Angle, deg., min.	Bottom Angle, deg., min.	Addendum, Axial	Addendum, Normal	t Axial	t Normal	$D+f$ Axial	$D+f$ Normal	Lead
Single	1-7-12	6-21	5-12	8-31	.3183	..	.500	.497	.6866	..	1.00
Double	2-8	12-32	10-18	16-40	.3183	..	.500	.488	.6866	..	2.00
Triple	3-9	18-27	15-24	23-48	..	.302	.500	.475	..	.651	3.00
Five	4-10-11-13-14	29-4	24-57	35-38	..	.278	..	.437	..	.600	5.00
Five	5	29-4	24-27	36-48	.3183	..	.500	.437	.6866	..	5.00

or normal, it is very difficult to make the hob, as the tool must have such excessive clearance at the point that it may not be possible to make the hob with a tool that can be sharpened without changing its thickness. Also, the hob tends to drag on the side, and any distortion in the hob or in the worm, due to hardening, interferes very much with the meshing of the worm and wheel. The differences in the shape of the various sections of a five-

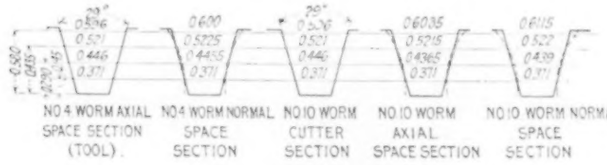

FIG. 3 FIVE-THREADED WORMS

threaded worm as made with the straight-sided tool are shown in Fig. 3.

Worm No. 10 has five threads, and was cut with a 29-deg. included-angle cutter, 3½ in. diameter, and the differences in shape between tools fitted to the normal and axial sections of No. 10 worm may be compared with the normal and axial sections of worm No. 4.

When the helix angle is greater than 18 deg., it is well to consider using a greater pressure angle. To illustrate, worms No. 11 and 13 were made and cut with a cutter whose sides formed an included angle of 50 deg. No. 11 was cut with a cutter of 3½ in. in diameter and No. 13 with one 6 in. in diameter. This change in size of cutter was made to show the difference in shape produced by two cutters of different diameters.

The most durable pair of worm gears is that with a hardened and ground worm. If the worm is to be ground, the shape of the worm thread must be such that the thread surface can be readily reached, and when the wide angle cutter is used this is possible. The best cutter to use is the one that will give ample working space. This angle should be no greater than is necessary to obtain such results, as the smaller the angle the better, because the pressure on the bearings varies about as the tangent of the angle of pressure.

Worm No. 13 might be considered as having been ground with a wheel 6 in. in diameter, and the difference in the shape on the axial and normal sections between Nos. 11 and 13 is shown in Fig. 4. A worm might be cut as No. 11 with a cutter 3½ in. in diameter and ground readily with a wheel 6 in. in diameter. The error is principally at the outside of the worm thread, since there

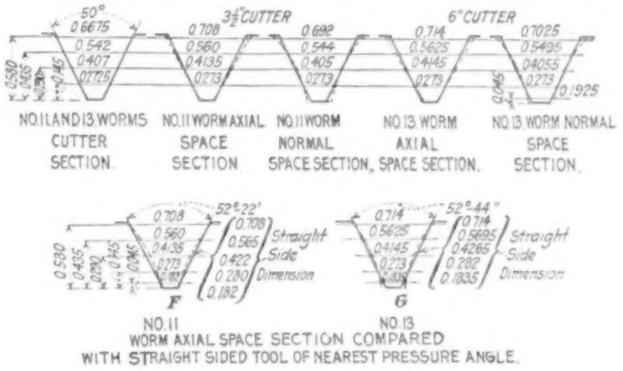

FIG. 4 FIVE-THREADED WORMS

is a decided rounding off at this point. The hob made to conform to the finished worm would produce a shape to suit the ground worm. Fig. 4 shows, at F and G, how nearly straight the sides of the teeth are on both No. 11 and No. 13, a tool fitted to the axial section being compared with a straight-sided tool. This is also interesting, as it forestalls the fear that there may be a loss in efficiency due to the lack of straight-sided teeth on the axial section. Another advantage of this cutter is that it has straight sides, which, as a starting point to make a worm or hob,

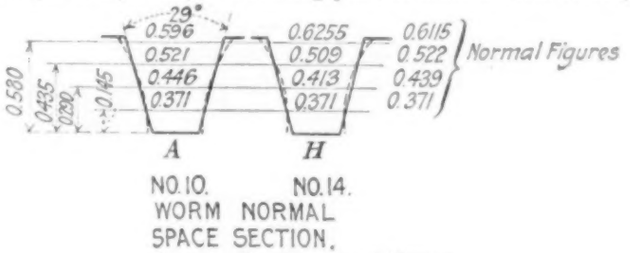

FIG. 5 FIVE-THREADED WORMS

is most simple. This cutter can also be made as an ordinary milling cutter which cuts more freely than a formed cutter which must be used if the section is other than that produced with a straight cutter.

If it is known that a given included angle is the basis for the cutter, it can be produced by any one, even if its diameter is not known, as quite a difference in cutter diameters can be used without any serious difference in shape. It must be borne in mind, however, that the greater the angle of the cutter, the less is the variation in shape due to the diameter of cutter.

Another method of producing worms with five threads would be to hob them. Worm No. 14 was cut with a single-threaded 14½-deg. pressure angle hob (29 deg. included angle), and the shape of the space on the normal is shown by dotted lines in Fig. 5, at H; this is compared with the normal section of worm No. 10, Fig. 3, and is reproduced at A, Fig. 5. It is apparent that this method produces something quite different and a shape that cannot be readily ground. If a hob of 25 deg. pressure angle or 50 deg. included angle on the axis was used, the shape produced would be much nearer that of worms Nos. 11 and 13.

That there is a general lack of knowledge of the foregoing facts is apparent to any one who is familiar with the manufacture of worm gears and the tools for producing them. It would be desirable to establish and follow a standard line of procedure as the use of worm gears is increasing rapidly. Any method adopted, however, should be based on simple principles, such as straight-sided cutters with a change in pressure angle at some stated angle of helix and a change from axial to normal depth at the same point, and the desirability of this latter method is due to its mechanical advantages and not to any theoretical ones.

Modern Electric Furnace Practice in Foundries

By W. E. MOORE,[1] PITTSBURGH, PA.

In this paper the author first enumerates the superior properties of electric steel and then points out the advantages of the electric furnace over the open-hearth method. He also discusses the features of the various classes of arc furnaces which have made that type practically supreme in the field. Following this the crucible and converter processes are briefly described and it is shown how the acid type of furnace is best suited for foundry work. Comparative operating costs of producing liquid steel by the converter and electric-furnace processes are also given, and these bring out the marked economy of the latter. The paper concludes with notes on the employment of the electric furnace in malleable-iron foundries, and on the selection of the most suitable type of furnace for a given installation.

UP to the present time the electric furnace has seen its largest commercial development, first, in the manufacture of aluminum, second, in the manufacture of steel, third, in the manufacture of ferroalloys, and fourth, in the manufacture of calcium carbide. At the end of 1913 there were only nineteen electric furnaces installed in the steel-making industry in America. This number had increased to 136 at the end of 1916, and to 269 at the end of 1917. At the present time the number of steel-making furnaces in use in various industrial countries of the world is 815, of which 290 are in the United States and 45 in Canada.

The average capacity of these furnaces in America is 0.37 tons per heat when used for ingots, and in the foundry business, 1.7 tons per heat, though the ordinary size now most generally used in foundries is the 3-ton. More than 99 per cent of all the steel-making furnaces are of the arc type, less than 1 per cent being of the induction type, which was popular in the early days of the art.

Electric furnaces are used for the following principal purposes in the metal industries:

a Forging steels, tool steels, alloy steels, etc.
b Making steel castings in foundries
c Making high grades of strong cast iron for difficult or fine castings
d Melting brass, bronze and other non-ferrous metals.

Properties of Electric Steel

Primarily, electric steel became popular because of its superior physical properties. While such steel can be made with a more satisfactory chemical analysis, using a given grade of raw materials, than by other processes, experience has abundantly demonstrated that when made according to the same chemical analysis it will have about 15 per cent greater tensile strength or ductility, depending upon its heat treatment, and that it is more resistant to shock and better able to receive heat treatment. The reason for this is that the steel, being made in a closed furnace and in a reducing atmosphere away from the contaminating influences of combustion gases, is more solid, freer from gases, and less prone to non-metallic inclusions of slag oxides. As an example, the tests in Table 1, made by R. W. Hunt and Company, Chicago, January 30, 1919, for the Chicago Surface Lines, illustrate the physical properties of A.E.R.A. specification heat-treated electric-furnace axle steel. It was heated from 1450 to 1460 deg. fahr. held one hour, quenched in 65-deg. oil, drawn from 1185 to 1200 deg. fahr. for one hour and then slowly cooled in the furnace. The open-hearth steel was also heat-treated in the same manner.

TABLE 1 COMPARISON OF OPEN-HEARTH AND ELECTRIC-FURNACE STEEL

	Open hearth	Electric furnace
Elastic limit, lb. per sq. in.	41,060	64,850
Tensile strength, lb. per sq. in.	89,100	105,140
Per cent elongation in 2 in.	21.5	22.0
Per cent reduction of area	31.74	52.37
Elastic torsion	16,750	33,700
Character of fracture	Granular	Silky cup

The Bureau of Standards reports regarding the superior qualities of electric steel as follows:

The characteristics of electric steel are great homogenity and freedom from segregation. It is somewhat higher in tensile strength and elastic limit than other steels and owing to its greater density, shows a marked resistance to fatigue.

Being absolutely "dead" when properly made and averaging lower in sulphur, electric steel in the foundry is less liable to show shrinkage cracks between ribs of castings, and, being more fluid, it is not so liable to piping, blowholes, cold shuts or misruns, and in tool steel it takes heat treatment more effectively and will stand greater abuse in heating.

The electric furnace is especially useful for making alloy steels. Since the metal is treated in a reducing atmosphere, there need be no large losses of the added elements, such as silicon, manganese, vanadium and chromium, which in the ordinary open-hearth practice are oxidized in large quantities and carried to waste in the slag, thus producing uncertain mixtures. Indeed, the added elements in open-hearth practice frequently show losses of from 30 to 50 per cent, while in the electric furnace they will be practically nil.

With the electric furnace it is much easier to carry the finishing operation to a more exact limit in carbon and silicon content than is practicable in the case of the open-hearth furnace. Gases of solution and inclusion, such as oxygen and nitrogen, are also eliminated.

Electric Versus Open-Hearth Furnaces

In open-hearth furnaces it is impracticable to melt down fine scrap, such as turnings in quantity without excessive additions of pig iron, for the reason that the oxidizing flames, which furnish the heat to the furnace, will reduce the metal when in an attenuated form to a mass of oxide before it becomes molten, whereas with the electric furnace it is entirely practicable to melt turnings exclusively, which, under ordinary market conditions, are purchasable at a price from five to ten dollars per ton lower price than that for the heavy melting grade of steel required in open-hearth practice.

In the electric furnace it is possible to obtain a heat-transfer efficiency of from 60 to 70 per cent of the heat energy of the electric power supply put into the molten charge, whereas with open-hearth practice the efficiency ranges from 8 to 15 per cent and in a crucible practice from 2 to 6 per cent. The fuel-developed heat unit of the open-hearth furnace is, however, bought in a much cheaper form than the heat unit supplied by electric power, and if the electric furnace did not have the other advantages mentioned it could not at present compete against the open-hearth furnace on the basis of cost.

On account of the very intense heat of the electric arc, it is entirely feasible to melt down and refine a charge of foundry steel in one hour or less which in the open-hearth furnace might require from 6 to 14 hours. In other words, a 12-ton electric furnace may be practically equivalent to an 80-ton open-hearth furnace, so far as steel output is concerned, and involve far less installation cost.

The Arc Type of Electric Furnace

The arc type of electric furnace is practically the only one being installed for steel making today, although induction-type fur-

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naces are in use. At first glance the induction-type furnace appears to have many advantages over the arc-type furnace, but practice has shown that it is in no way a competitor of a properly constructed arc furnace. In large sizes the power factor is extremely low, the efficiency of the furnace poor, and the cost of replacing the refractories very high.

Arc furnaces may again be classified into long-arc and short-arc types. There are many theoretical inducements for using the long-arc furnaces. With a given energy input, the electrode is correspondingly smaller and the electrode cost therefore reduced proportionately. With the water-cooled bottom-contact type of furnace either the furnace size must be kept small or the voltage must be greatly increased in order to keep the current low and prevent that form of contact from overheating; hence, it is the custom to operate the bottom-electrode furnace with quite a long-arc and low current, and in small sizes only.

Arc furnaces may again be classified into single-phase, two-phase and three-phase types. The single-phase furnace is ideally simple but is poorly adapted to modern power-plant conditions, as central-station power today is universally generated and transmitted in three phases. The long-arc single-phase furnaces, too, have the very great disadvantage of operating on extremely low power factor, thus causing a great waste in transformer, line, and generator capacity, which usually makes them prohibitive from the central-station man's viewpoint in any but quite small sizes, say ¼-ton to 1-ton capacity per heat.

The two-phase furnace may be operated either from two or three-phase power, but when operated from the usual three-phase power the phases have to be transformed by Scott-connected transformers, which are more costly, less efficient and frequently unbalance the power system. The two-phase furnace is usually built with four arcing electrodes and, while it gives a theoretically balanced load on the power system, it has the objection of requiring an additional electrode, which increases the electrode consumption 33 per cent over the three-phase furnace.

The three-phase furnace for installations of moderate and large size is the most universally satisfactory and popular furnace, fulfilling all the conditions as to balanced load and high-power factor required by the central stations, at the same time giving the minimum electrode loss and the simpliest form of automatic-electrode-adjusting gear.

It is possible to obtain satisfactory operation of the direct-arc-type furnace for melting non-ferrous metals only where the content of metals which volatilize at low temperatures is small, as, for instance, in making bronze and low-zinc metals. Where the zinc or aluminum content is high, as in yellow brass, Muntz metal, etc., this type of furnace is very unsatisfactory and results in great waste of the more volatile metals and the making of porous castings. Consequently special furnaces of the resistor, rocking, rolling, tumbling induction or distributer-arc types are required, the latter referring to furnaces in which the heat of the arc is transmitted by radiation alone.

Disadvantages of Crucible Furnaces

The crucible furnace is the oldest method for making steel castings and of making first-class tool steels. However, it is now being practically displaced by the electric furnace, which has many advantages such as rapidity and reduced cost, and the ability to make sounder castings and better tool and alloy steels. Due to the absorption of carbon from the crucible, it is difficult to make castings low enough in carbon to obtain the ductility desired for many purposes. Furthermore, the steel reduces the silica from the clay of the crucible, tending to run the silicon content of the product high. The overpowering objection to the crucible process, however, is the high cost of the products, due to:

a High cost of pure melting stock, as no refining is practicable

b Very high labor cost on account of the small heats handled

c Extravagant fuel consumption, sometimes using 3 tons of coal per ton of steel

d High cost of crucible renewals, often averaging two to four crucibles per ton melted and costing $9 to $11 each or $18 to $44 per ton.

For these reasons the crucible-melting shop is rapidly going out of use for castings, as well as for tool steels.

The Converter Process in Steel Founding

During recent years the side-blow converter process has become very popular in steel foundries making castings of medium and small size. This process requires high-grade, high-silicon, low-phosphorous and low-sulphur pig iron to be melted in a cupola furnace with the finest grade of coke obtainable. The advantages of the converter process are: The steel may be made fluid enough for reasonably thin castings; the heats, usually running one to two tons, are of convenient size to be poured off quickly before cooling; the fuel consumption is moderate, averaging from 400 to 600 lb. of coke per ton; the first cost of the apparatus is low, and the process is available for intermittent service.

The disadvantages are: The metal must be handled twice in the ladle; the metal picks up sulphur and phosphorus and nitrides from contact with the fuel and the air blast; the losses in the cupola and converter are quite high, running from 16 to 24 per cent, further concentrating and increasing the percentages of impurities in the original metal and wasting costly melting stock; the steel is full of oxides and gases and requires large quantities of expensive ferroalloys to kill; the quality of the steel physically, as well as chemically, is below par; a heat once blown too cold cannot again be brought up in heat enough to cast and must be "pigged"; only the highest grades of melting stock may be used, costing generally $15 to $25 per ton more than for the acid open-hearth furnace and $20 to $35 per ton more than for the electric furnace; and the refractory maintenance is high, as the cupola and converter linings must be repaired after each 10-hr. run. Liquid-metal costs of converter steel frequently run up to from $60 or $80 per ton.

The electric furnace is the most modern steel-producing agency and is gaining in popularity more rapidly than all others. It is the most compact furnace, and the rapidity with which it will melt down cold charges adapts it splendidly to the making of steel castings, as well as forging and tool steels. It is the cleanest and most certain method of making steel, and its small bulk makes it feasible to locate the furnace near the center of the floor where the metal need be transported short distances only.

Acid-Type Electric Furnace for Foundry Work

The acid-type furnace is best suited for foundry work and the most popular size has a capacity of 3 tons per heat, though sometimes 1.5-ton or smaller furnaces are required. The more highly powered and rapid furnaces for such work turn out from 8 to 16 heats in 24 hr., and with a power consumption of from 500 to 650 kw-hr. per ton of liquid steel and considering the ultimate efficiency of the large modern turbo-generator power house at, say, 1.5 lb. of coal per kw-hr., its fuel consumption might be said to be equivalent to from 750 to 900 lb. of coal per ton melted, and the coal need not be of high grade nor low in sulphur and phosphorus as is necessary with fuel-fired furnaces. Basic furnaces require more time and power, heats ranging from four to eight per day, and since the charge is melted in a reducing atmosphere there is practically no oxidation of the metal; consequently thin scrap, light turnings or scrap of other forms such as can be conveniently charged into the furnace, may be melted. Such scrap on the present market sells for approximately from $5 to $10 per ton less than low-phosphorous, heavy melting scrap necessary with the ordinary acid open-hearth melting-furnace installation.

The furnace atmosphere, being of a reducing nature, makes it easier to refine and kill the steel, resulting in a saving amounting frequently to half of the ferroalloys necessary with converter steel, effecting a saving of, say, $2 per ton. The melting losses in the electric furnace are much the lowest of any modern process, aver-

aging from 2 to 5 per cent as against 6 to 9 per cent in the open-hearth and from 16 to 24 per cent in the converter process.

The electric furnace does not contaminate the metal as do fuel-heated furnaces and an acid electric will therefore readily make No. 3-U.S.A. specification steel, whereas it nowadays is practically impossible to find melting stock sufficiently pure to do so with the converter process. The saving alone in the cost of melting stock will more than pay for the entire conversion cost of electric steel. The greatest points in favor of the electric furnace are the much higher grades of steel produced and the higher percentage yield in castings and bars.

Comparative Costs of Electric and Converter Steel

With the electric furnace, men can more readily make and check their steel to an exact percentage of carbon, manganese and silicon and can more easily keep the undesirable sulphur and phosphorus to low limits than by any other process. The steel may be readily alloyed with nickel, chromium, and vanadium to make the higher grades of steel castings to replace forgings and for special purposes, such as may be required for parts of unusual strength, ductility or for cutting tools. It is entirely feasible to make castings which will run up to an ultimate strength of 130,000 lb. per sq. in., or to cast high-speed-steel milling cutters and reamers to form for grinding. The figures in Tables 2 and 3 show present-day comparative operating costs for liquid steel in the ladle under favorable conditions as in a steel foundry under 24-hr.-per-day operation.

TABLE 2 AVERAGE COST PER TON FOR TWO TONS OF CONVERTER STEEL DIVIDED INTO FOUR CUPOLA CHARGES

Two-ton Converter Charge	Cost per ton of liquid steel
Low-phosphorous pig iron	$14.09
Bessemer pig iron	7.89
Steel scrap	10.14
Silicon and spiegel	5.55
Coke, 863 lb.	1.01
Cost of material per ton of liquid steel	$38.68
Additions per ton of steel:	
10 lb. 80 per cent ferromanganese at 6 cents	$0.60
6 lb. 50 per cent ferrosilicon at 5 cents	0.30
2 lb. aluminum at 30 cents	0.60
Power for blower motors	1.25
Cost of materials and power per ton of liquid steel	$41.43
Average cost of cupola and converter linings	1.20
Labor costs	3.00
Cost of converter steel per net ton in ladle	$45.63

TABLE 3 AVERAGE COST PER TON FOR THREE-TON ACID-LINED, RAPID-TYPE, POLYPHASE, ELECTRIC FOUNDRY FURNACE STEEL

Three-ton Electric Furnace Charge	Cost per ton of liquid steel
Axle turnings (included above 3 per cent losses, 200 lb.)	$12.40
Mill scale (included above 60 per cent losses, 60 lb.)	0.09
Electrodes at 7 cents	1.40
1650 kw-hr. (550 per ton) at cent per kw-hr.	5.50
Losses in melting 260 lb.:	
80 per cent ferromanganese	0.40
50 per cent ferrosilicon	0.25
Aluminum at 30 cents	0.15
Cost of material per ton of liquid steel	$20.19
Average cost of linings and roofs	0.40
Labor cost on furnace attendance	1.00
Cost of electric steel per net ton in ladle	$21.59

G. K. Elliott reports a cupola iron showing a transverse load of 2950 lb. with a 0.10-in. deflection in a standard arbitration test bar. After 25 min. treatment in the electric furnace, using 104 kw-hr. per ton, a similar bar was cast and broke at 4400 lb. with a 0.115-in. deflection.

Very fine results have been obtained with malleable iron made by treating cupola metal or by melting cold scrap in an electric furnace. The ability to refine for sulphur and phosphorus and to add ferroalloys to adjust the mixture to the proper malleabilizing formula, together with its very rapid operation, give the electric furnace a decided advantage in malleable-iron foundries, particularly in working on high-phosphorous southern irons.

In the non-ferrous-metal industry the electric furnace has shown remarkable economies, due to the saving of cost of crucibles and the greatly reduced metal losses caused by oxidation and volatilization. For such work special types of furnaces designed to avoid localized heating are necessary.

Selection of an Electric Furnace

As to the most suitable type of electric furnace for a given installation, if the scrap be inferior and high in sulphur and phosphorus, then the extra cost, slower operation, and shorter refractory life of the basic furnace must be endured to obtain the lower limits of sulphur and phosphorus not practicable to reach with the acid furnace using poorer grades of scrap. At present the call is for acid-lined furnaces, and cheap, good scrap is available in large quantities for foundries, and basic furnaces for alloy and tool steel. The acid furnace is simpler, cheaper and faster to operate and the steel casts more easily, while the basic furnace is essential for tool steels.

It is strongly recommended in any case that a furnace be so designed and constructed that it is adaptable to basic operation. This means that the furnace shell must be of large diameter and the bath of large area and shallow. The furnace should not, it is thought, be of the long-arc type, nor of the small-diameter, deep-bath type if the best and most rapid work is contemplated. Indeed, even for acid melting there is a noticeable difference in the quality of the steel obtained from the large-diameter, shallow-bath furnaces compared with that made in the deep bath-type furnace, for with the latter it is not feasible to obtain the same mechanical reactions from the additions put in to refine and kill the steel as when the bath is of the shallower type. Nor is it possible so thoroughly to deoxidize the metal by maintaining a reducing atmosphere in the furnace.

It is quite important that the furnace should operate at the highest practicable power factor that can be obtained without undue disturbance of the power company's load, for by so doing the electrode, transformer, line and generator losses are maintained at a minimum. Engineering skill of a high order is required to forecast and select the best type of equipment, under the many varied power-supply conditions which obtain in different localities.

By reason of the now generally acknowledged superior quality of the product, greater flexibility of operation, quicker, more-convenient-sized heats, and saving in alloys and in cost of melting stock, the electric furnace is rapidly coming to the front in the steel foundry and alloy- and tool-steel works wherever suitable power is available and progressive policies are in vogue. It is making possible the profitable operation of widely distributed small steel foundries to an extent not generally realized and greatly reducing the investment cost required in tool-steel works.

That weaknesses are developed in steel by aggregations of impurities, notably sulphur, which are forced into position in the processes of rolling or forging, is asserted in a paper by Mr. Portevin, published in *Comptes rendus des séances de L'Académie des Sciences*, for August 11, 1919. In the *Journal of the Iron and Steel Institute*, vol. 85, 1912, p. 379, Roger has outlined a method of applying an acid solution of silver bromide to uneven surfaces by using a plastic mixture of clay, wax and vaseline. Mr. Portevin examined the variation in the appearance of fractures in steel test pieces, according to the direction of the line of fracture with respect to the fiber of the steel, given to it in the process of rolling or forging, by substituting for Roger's mixture a paste composed of gelatine, glycerine and water covered with an emulsion of silver bromide. Evidences of aggregations of sulphur were found in all specimens thus examined. It would appear, therefore, that the only means to prevent such aggregations is to keep the sulphur out of the ingot. This can be best effected in the opinion of Mr. Portevin by reducing the disengagement of gas in the pouring of the ingot and employing ingots of as small size as compatible with the use to which steel is to be put.

A Perfected High-Pressure Rotary Compressor

By CHESTER B. LORD,[1] ST. LOUIS, MO.

Of the three types of rotary compressors, namely, the centrifugal blower, the gear type and the eccentric rotor with telescopic blade, the last is the least efficient. Particulars are given by the author of a new and improved construction of this type in which leakage, friction and packing troubles have been eliminated to such an extent that a volumetric efficiency of 92 per cent at seven compressions (100 lb. per sq. in.) is said to be commercially obtainable. It is also stated that this compressor will, without adjustment or alteration, handle gas, air, or a liquid, or a gas and a liquid at the same time, and that it is possible to obtain a pressure of 500 lb. in a single-stage machine and 1000 lb. in three stages with the three units on the same shaft. The uses of the rotary compressor are also enumerated in the paper and its special advantages are set forth, these being (1) small weight per unit of capacity, (2) small amount of floor space required, (3) small initial cost of installation, (4) employment of direct drive, (5) small amount of headroom required, (6) simplification of construction and small amount of adjustment or repair, and (7) self-lubrication.

ANY one familiar with the various lines of mechanical endeavor must realize that no vital change has been made in compressors in the last thirty years or more. There have been improvements in the way of better valves, a little higher speed and minor matters of this kind, but none of them has changed the principle of the machine or resulted in any great economy either in weight, operating space required, or cost of installation. Moreover, these machines require a great deal of attention, and necessary repairs are expensive because in almost every case the machines must be partly taken down in order to get at the parts to be repaired, the bearings are numerous and are lubricated with difficulty, and the valves must be adjusted in a very delicate manner to give best efficiency. Because of all these disadvantages in the reciprocating machine we are constantly striving to get on a unidirection basis in the mechanical world. We are replacing the reciprocating planer with a unidirection miller and introducing the uniflow principle in the reciprocating engine. The automotive world is searching for the unidirection gasoline unit, and the Patent Office records are full of rotary valves, rotary engines, and rotary pumps.

The rotary principle, however, is so valuable that in spite of their deficiencies three general types of rotary compressors have been retained, namely, the centrifugal blower, the gear-type compressor, and the eccentric rotor with a telescopic blade. The centrifugal blower depends more upon the velocity of the air than upon compression and requires several stages to secure any considerable degree of compression. The gear-type compressor which, roughly speaking, compress air between two gears with their teeth in mesh (taking it in at one side of the teeth and delivering it at the other) has a very low efficiency, but is able to compress to a higher degree, single-stage, than either of the other types. None of them, however, compresses to over 8 or 10 lb. single-stage.

The eccentric-rotor-with-telescopic-blade type of rotary compressor has been faulty in several respects. The first and greatest was that it was necessary to maintain a seal at one point between the rotor and the cylinder. This was a source of large friction losses and the seal was soon broken by wear. Second, the blade pressure against the end plates and the inner surface of the cylinder created great friction loss and still further wore the cylinder at the contact point between the rotor and the cylinder wall. Third, the pressure being all on one side of the blade created such friction that the blade did not work in and out freely. It was also found impossible to devise a method of packing square corners, and hence the only commercial application of this type was in the pumping of oil or water at a comparatively high velocity, which service produced the least friction and no important losses.

The New Rotary Compressor

As the result of long, patient research and the ingenious application of obvious principles, these faults enumerated have been eliminated and a new compressor perfected by W. G. E. Rolaff, of Belleville, Ill.

The difficulty of maintaining a seal at one point between the rotor and the cylinder is fundamental. Some years ago a Mr. Hermansen developed an engine in which the cylinder revolved at the same peripheral speed as the rotor and was, in fact, carried by the rotor. Having both moving parts traveling at the same peripheral speed, not at the *same angular* speed, means that there is no slip between the two, consequently, little or no friction. It also reduces to a minimum the blade friction against the outside of the cylinder because the movement of the blade on the wall of the cylinder per compressive revolution is only that represented by the difference in the circumferences of the outside of the rotor and the inside of the cylinder. In other words, in a 100-cu. ft. size with a cylinder 10⅝ in. in diameter and a rotor 10 in. in diameter, the blade travel per compressive revolution is only the difference between 31.41 in. and 33.38 in., or less than 2 in., so that it requires approximately 17 revolutions of the rotor for one revolution of the blade upon the cylinder wall. There are no valve openings in the cylinder, and as it travels always in the same plane it makes no difference whether the cylinder is revolving with the rotor, standing still or reversing itself, as far as compression is concerned. Hermansen's principle, by itself valueless, was evolved by Mr. Rolaff who at that time was unaware of the Hermansen patent which he afterward acquired.

The difficulty of excessive end pressure was overcome by floating plates at the ends of the cylinder held in intimate contact with the rotor by pressure generated by the machine itself. The pressure upon the outer surface of the plates is greater than upon the inner surface by reason of the difference of the area exposed to this pressure. This supplemental pressure is always in direct proportion to the pressure generated by the machine, hence the additional friction is only what is necessary to keep the cylinder heads in close contact with the rotor and cylinder ends, and where the pressure is even slightly greater on the outside than on the inside there can be no leakage. Any motion imparted to the rotor shaft will immediately be communicated to the cylinder by reason of the metal-to-metal contact between the two. In other words, if the rotor is revolved the cylinder will revolve with it and the cylinder plates will float with the cylinder or piston or between the two, as the case may be. The friction developed is merely the friction of the wiping contact between the rotor ends and the cylinder plates, since there is very little or no friction in the rolling contact between the rotor and the cylinder.

There still remained the question of packing square corners and of friction between the ends of the blades and the end plates. When the rotor is revolved, the piston blades which fit loosely in the slot fly out by centrifugal force and remain in contact with the cylinder wall and the cylinder heads, since centrifugal force acting on a wedge keeps them in such contact. This is the principal point of friction. But calculating this friction on the basis of speed in feet per minute, we find, for instance, that on a machine capable of compressing 100 cu. ft. of free air per min. the piston-blade travel is approximately ⅝ in., and since a machine of this type would run at about 900 r.p.m. we have the following calculation: $\frac{5}{8} \times 2 \times 900$, which gives 93 cu. ft. and since the surface in contact with the cylinder heads is very small, the total amount of friction generated by this reciprocating action of the piston blade is proportionately small.

[1] Cons. Mechanical Engineer, Wagner Electric Manufacturing Company, St. Louis, Mo. Mem.Am.Soc.M.E.

For presentation at the Annual Meeting, New York, December 1919, of The American Society of Mechanical Engineers. The paper is here printed in abstract form, and advance copies of the complete paper may be obtained gratis upon application. All papers are subject to revision.

These blades as developed are of two types, centrifugal and pressure. At present, the centrifugal type shown in Fig. 1 is used commercially. This blade consists of four parts, one of which, *A*, is cut away as shown and on it are imposed three thin blades, *B* and *C*, of any desired metal. The two outside pieces *B* are beveled and the center piece *C* fits between these, forming a wedge, and the top of *C* is cut away to allow of movement vertically. Revolving at speed the center piece *C* is thrown out by centrifugal action, the force exerted on the pieces *B* being in the direction of the arrow. This presses the *B* pieces against the sides and ends of the cylinder. These blades are self-aligning and self-adjusting, also self-compensating. The force with which these blades *B* strike against the corners is regulated by the angle of their inner sides and the weight of the center piece. There are no springs whatever and the blade is balanced for back pressure by having both sides exposed to chamber pressure with a seat at the top of the slot in back, and as oil from the cylinder wall is scraped off by the blade into the slot, an effective seal is maintained. The blade *A* is about 1/32 in. short on each end and makes contact with the cylinder wall except at the extreme corner and side. The discharge valve is immediately in front of this blade. In machining the rotor and the cylinder where a rolling contact is maintained between the two, the turning of the cylinder too large or the rotor too small would destroy contact. For making contact, a circular wedge is used. This is an eccentric cradle carrying the bearings for the revolving cylinder and is made with a threaded stud led through the outer casing. In practice the rotor and cylinder are assembled without contact and

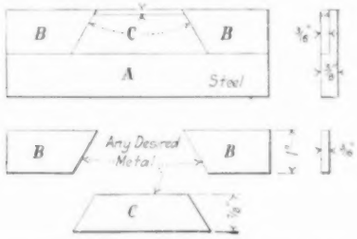

FIG. 1 CENTRIFUGAL TYPE OF BLADE FOR USE IN ROTARY COMPRESSOR WITH ECCENTRIC ROTOR

started on test. After a time, by drawing up on the wedge, the proper contact is made. When this is found, the nut is backed off about 1/4 turn, so that on a 500-cu. ft. compressor the space is about 0.01 in., the oil making a proper seal and contact. Capacity can be increased by taking a cut off the cylinder or rotor, or both.

One of the greatest advantages of the compressor is that it may be direct-connected. It can be run at any speed at which a prime mover can be run safely. A 100-ton refrigerating machine is run at 600 r.p.m., a 1-ton or 5-cu. ft. size at 1800 r.p.m. That the piston speed is not too high for efficiency is shown by data on a reciprocating compressor of 14-in. stroke and having 100 cu. ft. capacity at 200 r.p.m. The piston speed would be 466 ft. per min., or over 200 per cent in excess of a rotary compressor of the same capacity run at 900 r.p.m., with a relative speed of 150 ft. per min. between the rotor and cylinder. The next advantage is in its space requirements. A 100-ton rotary compressor on its base with its prime mover requires only 60 sq. ft. of floor space, whereas a horizontal reciprocating unit of the same capacity requires approximately 1200 sq. ft. plus a building, plus a boiler room, and weighs 100 lb. per ton capacity as against approximately 8 lb. for the rotary. It is usually possible to replace any pump or compressor with a machine weighing less than the flywheel of the displaced unit. With the high-pressure rotary compressor, the volumetric efficiency at 100 lb. pressure is 90 to 92 per cent, depending on size, as against 65 to 85 per cent with the reciprocating machine.

The rotary compressor without adjustment or alteration will pump gas, air, or liquid, or all three. When ammonia condenses in the coils of a refrigerating machine and a "slug" happens to get into the compressor, usually a valve or a cylinder head is blown off. A 5-gal. tank of oil can be poured into a rotary compressor running at full speed under load, as fast as the inlet pipe will take it. Since the end plates are held to the cylinder only by differential pressure, if the oil entering the cylinder cannot be discharged fast enough by the valves, the end plates open up, allow the oil to pass out and then close. It is obvious that when pumping fluid continuously the pressures inside and out would again be different and be relatively maintained, so that no leakage would occur. In other words, the loose end plates act as safety valves without effort, as any necessary area of exit is secured and the oil leaves the cylinder at just sufficient pressure to raise the end plates. This feature is valuable in pumping hot water, or gas and oil.

Another feature of this construction is the possibility of making the compressor double-acting by placing two blades 180 deg. apart, which would add 60 to 70 per cent to the capacity of the machine. Until recently, however, no effort has been made to do this as it requires an intake valve, which is troublesome. In the simple type no intake valve is used, the seal between the rotor and cylinder acting as such. The major trouble with all air compressors, reciprocating or otherwise, lies in the valves, and the same trouble was found initially in the rotary compressor. It was aggravated somewhat in the rotary by the fact that cracking or splitting of the valve in its cage was not immediately preceptible, and it was possible for a valve to gradually break up into fine pieces and get into the cylinder. Experiments were undertaken to find a suitable material, and this has been done for cases where the temperatures do not exceed 200 deg. fahr. In the 100-ton size the discharge valve is about 24 in. long by 1/2 in. wide, so it will be seen that the problem differs from that of the reciprocating machine.

USES OF THE ROTARY COMPRESSOR

The uses of the rotary compressor include every one possible to a compressor of the reciprocating type and some that are not. It is possible to get 500 lb. pressure single-stage; to get 1000 lb. pressure in three stages with the three units on the same shaft; to make it a low-pressure machine, giving it any desired capacity by making the rotor relatively small; and to give even more than 1000 lb. pressure single-stage by reducing the displacement. As a vacuum pump it will pull 28 1/2 in. against a pressure of 180 lb., but to do this continuously with a compressor it is necessary to shut off the oil pipe, and for commercial practice it would be necessary to have a self-contained oiling system. The firm handling the rotary compressor in question has already been asked to consider the making of blowing engines for blast furnaces, as compressors of the rotary type do not take up more than 5 per cent of the room now necessary.

These rotary compressors are in use at the present time as boosters on refrigerating units for both high and low pressures. The small household refrigerating business has not grown because it had been found impossible to secure a dependable compressor. One manufacturer is at present building units using this rotary compressor. It is a 0.5-cu. ft. size, runs at 1760 r.p.m., is direct-connected and is perceptibly noiseless, as are all other sizes of this compressor. The rotor in this size is 1 7/8 in. in diameter and 1 in. long. Another manufacturer is making the 3-ton refrigerating size. Still another has a contract on which is guaranteed a minimum of 10,000 cu. ft. per year for street-car compressors. Another use is as a small individual unit for refrigerating cars, run either from the axle direct, or with a motor from a turbine in the engine. Upon arrival at terminals, instead of the expense and waste of icing, it will only be necessary to plug in.

Used as an air compressor, the rotary compressor is ideal as the air is taken off at the center and the oil thrown out centrifugally to the periphery. No rotary pump is at present made that will prime itself, but this is not true of the compressor when used as a pump. Further, although no reciprocating pump manufactured handles CO_2 successfully for any length of time without need of repairs because of the high efficiency and the character of its cylinder construction, there would seem to be little doubt of the rotary's ability to handle CO_2 continuously without repairs. This is in the future and also applies to hydraulic applications.

(*Continued on page* 905)

Common Errors in Machining of Bearings

By CHRISTOPHER H. BIERBAUM,[1] BUFFALO, N. Y.

The machining of bearings is a subject which has received but slight attention, and this despite the fact that it is an important one. To place on record some of the more common errors prevalent in this type of work, the author in his paper discusses the disadvantages of tight-fitting bushings, the methods of finishing brasses to provide for expansion while running, and the methods of clamping bearings during tooling. He also takes up the matter of the tools employed and shows by numerous photomicrographs of finished surfaces the importance of using sharp tools with the proper rake, in order that the crystalline structure of the surface material of the bearing may not be so crushed that it will fail to function as a normal bearing alloy.

IN the construction of journal bearings one matter which is very frequently neglected, perhaps most often because it is not thoroughly understood, is that of driving in bushings. As all bearing alloys have a temperature coefficient of expansion higher than that of cast iron, and as the bearing is directly subject to the friction of the journal, it follows that the bearing is at a higher temperature than the cast-iron housing and that all bearings must have an appreciable outward expansion when in operation. For this reason bushings should be driven in with just enough pressure to prevent looseness during operation.

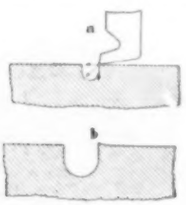

FIG. 1 SHARP EDGE PRODUCED AT THE EDGE OF AN OIL GROOVE BY AN ORDINARY LATHE TOOL

The practice of driving in bushings so tight that they require reaming before they can be put into service cannot be condemned too severely. The subsequent reaming does not remedy the evil, in that a bushing driven in so tight will and must continue to contract inwardly when in operation, since the outside pressure upon it is not removed by the reaming. In the tooling of a bearing a definite amount of clearance should be provided for, in order to insure the best service conditions. When a bushing is driven in too tight, although it has been reamed before being placed in service, the amount of clearance which it will then have becomes a matter of guesswork and the amount of oil-film space provided an uncertainty. This condition frequently gives rise to heating and bearing troubles, even though the amount of internal contraction may not be sufficient to positively grip or stop the journal. The idea that bushings must be driven in tightly in order to hold them in place is fundamentally wrong, and excessive tightness of the bushing in its housing should always be avoided. For all ordinary machinery it will suffice if a bushing may be driven in place with a blow of the hand or with a small block of wood. The provision of fastening the bushing in place should be such that it will not bind or clamp the latter against outward expansion.

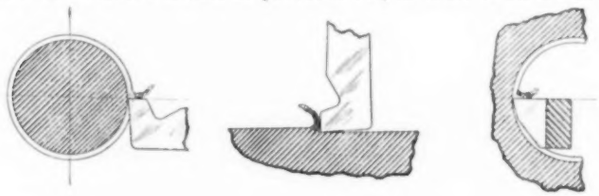

FIG. 2 IMPROPER FORMS OF LATHE, PLANER AND BORING TOOLS

METHOD OF FINISHING A CRANKPIN BEARING

The finishing of bearings in such a manner that they may expand while warming up is of very considerable importance, and this can be done in many cases by simply giving the matter the full consideration which it deserves. The two edges of the two half-bearings should be "brass bound," that is, they should bear solidly against each other and should exert a pressure against each other somewhat in excess of the maximum crankpin load. The outer surfaces of both bearings near these edges should be relieved so as not to bear upon the straps. The four corners of the bearings should be relieved in like manner so that the horizontal thrust will be mainly borne upon the surfaces falling within the area of the horizontal projection of the crankpin. A bearing thus constructed expands with the first slight increase of temperature, relieving the crankpin instead of clamping it as when these precautions are not taken.

CLAMPING OF BEARINGS FOR TOOLING

Another matter very often overlooked is that of the manner in which bushings or bearings in general are clamped during tooling. With a $\frac{5}{8}$-in. 16-thread set screw and the application of, say, a 50-lb. pull upon a 12-in. monkey wrench, a pressure of 50,000 lb. can be carelessly exerted upon the bushing in question, and it must be remembered that the composition of a bearing material is never one that would be selected for maximum strength. Bushings tooled when clamped in this manner seldom have a bore that even approaches a true cylindrical surface, and if they are then driven upon an arbor and finished on the outside a very inaccurate product is the result, a bushing that can never give the most satisfactory service. The best and most satisfactory method of holding bushings for tooling is that of clamping them endwise. The importance of this is very generally underestimated; in general, bearings should be held in a manner such as to produce the least possible amount of strain and distortion.

FIG. 3 CROSS-SECTION OF ONE OF THE TEETH OF A MOTOR-TRUCK-DRIVE WORM WHEEL

CHAMFERING OF OIL GROOVES EDGES

The matter of chamfering oil-groove edges deserves special attention in that all advance edges of a bearing should be rounded and chamfered off, and the fact that this work should be done last, after all of the other tooling of the bearing has been completed, is important. At *a* in Fig. 1 is shown an ordinary lathe tool at the edge of a groove on a finished surface. It is obvious that there are being exerted two forces upon any surface which is being tooled,

[1] Vice-Pres. Lumen Bearing Company, Buffalo, N. Y. Mem.Am.Soc.M.E.

For presentation at the Annual Meeting, New York, December 1919, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS. The paper is here printed in abstract form, and advance copies of the complete paper may be obtained gratis upon application. All papers are subject to revision.

one horizontal or parallel to the finished surface and the other vertical or in a direction normal to that surface. The resultant of these two forces is a force indicated by the dotted arrow, in a direction tending to deflect the edge of the groove obliquely downward: producing an effect which is shown somewhat exaggerated at *b*, Fig. 1. It can readily be appreciated what an injurious effect is produced in a bearing if any tooling is done after the oil grooves have been

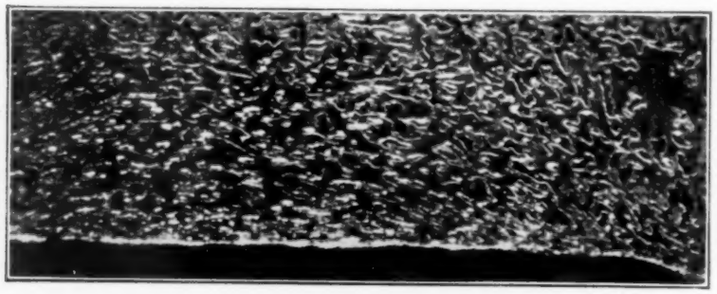

FIG. 4 PHOTOMICROGRAPH OF FIELD AT *a*, FIG. 3 (60 MAGNIFICATIONS), SHOWING DISTURBANCE OF CRYSTALLINE STRUCTURE DUE TO THE USE OF A DULL HOB IN TOOLING

cut, especially so if the direction of rotation of the journal is opposite to that of the tooling. In all cases sharp edges of the groove prevent the formation of an adequate oil film and should be carefully avoided.

WHY BEARING SURFACES SHOULD BE MACHINED WITH SHARP TOOLS

For best results it is very necessary and it is also general practice that a cutting tool should have rake. The tools shown in Fig. 2 would be readily condemned even by a person with a very limited shop experience, and no journeyman machinist would think of setting a lathe tool as shown at *a*, a planer tool as at *b*, or a boring tool as at *c*. In the case of the latter, the amount of normal or radial pressure which it exerts upon the finished surfaces is far in excess of what is necessary. Consider now the standard multiple-cutting-edge reamer which is very often used in finishing bearings. A 2½-in. reamer would have, say, 14 edges and the amount of bursting or internal pressure that it would exert within a bushing would be at least 14 times that exerted in case the bushing were reamed with only one improper tool as shown at *c*, Fig. 2. This practice is one that cannot be condemned too severely.

The final finishing in bearings should be done by reamers or cutting heads having only one or a very limited number of cutting edges, and these cuting edges should have the proper amount of rake, such as would be given to any other proper cutting tool. Experiments made in a large manufacturing plant on bushings of the same dimensions, from the same lot of material, finished at the same time (some, however, being reamed with the standard multiple-cutting-edge reamer and others with a single cutting blade) showed that after a storage of six months those bushings which had been reamed with a proper single cutting edge retained their accuracy and shape much better than those finished with the so-called standard reamer. The latter bushings exhibited a decided tendency to decrease in inside diameter and to assume inaccurate elliptical forms. It was also brought out at this time, that not only did a superior product result from the use of a proper tool, but that by its use the production could be increased from 15 to 20 per cent.

DEFECTS IN BEARING SURFACES REVEALED BY THE MICROSCOPE

Another reason why bearing surfaces should be tooled with sharp tools having the proper amount of rake is brought out by a microscopic study of bearing surfaces. In order to obtain the full value of bearing alloys it is necessary that these alloys should be presented as bearing surfaces having their natural crystallization undisturbed. The reason for this is given in the report of the Society's Research Sub-Committee on Bearing Metals.[1] The hard or bearing crystals should be embedded in a softer material, permitting the former to adapt themselves to the journal surface; the softer crystals under proper service conditions will wear slightly below the surface of the harder crystals. In order to retain these conditions it is necessary to preserve the natural crystallization upon the bearing surfaces, but this cannot obtain where they have been mutilated by improper tooling. This mutilation of the bearing surfaces gives rise to the crushing of the harder crystals and embeds these crushed particles into a compressed material which does not function as a normal bearing alloy.

A very forcible illustration of this is furnished by the bronze worm wheel of a certain motor-truck drive in which the teeth had been finished with a dull hob, Fig. 3, showing a cross-section of one

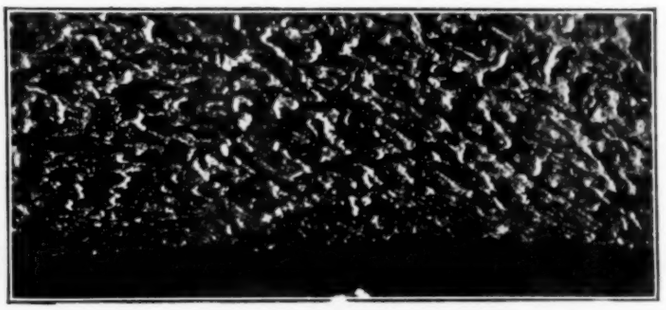

FIG. 5 PORTION OF FIG. 4 MORE HIGHLY MAGNIFIED (120 MAGNIFICATIONS), SHOWING CLEARLY THE COLD-ROLLED EFFECT ON THE BEARING SURFACE OF THE TOOTH

of the teeth. After giving unsatisfactory service the worm wheel was examined in the usual way by chemical and physical tests, neither of which showed any defect whatsoever. On the other hand microscopic examination showed that the trouble was due to improper tooling. Fig. 4 shows a photomicrographic section of a field at *a* in Fig. 3. This view clearly shows that the natural crystallization of the greater part of the area has been disturbed, and that the edge of the tooth has had a cold-rolled or wire-drawn

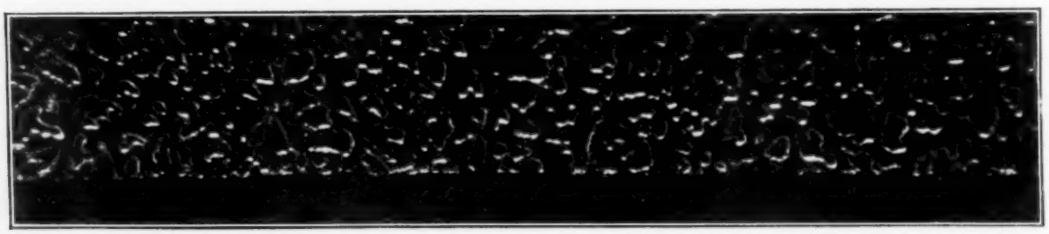

FIG. 6 PHOTOMICROGRAPH OF EDGE *b*, FIG. 3 (90 MAGNIFICATIONS), SHOWING THAT A SHARP TOOL WITH SUFFICIENT RAKE WILL NOT DISTURB THE CRYSTALLINE STRUCTURE

effect produced upon it by improper tooling. It is true this effect is not very deep, nevertheless it is the very surface which is brought into play when the worm wheel is put in operation. Fig. 5 shows a part of Fig. 4 more highly magnified, in which the cold-rolled effect upon the surface is seen to be even more complete, a condi-

(*Continued on page 907*)

[1] Presented at the Spring Meeting, June 1919.

Kerosene as a Fuel in High-Speed Engines

By LAWRENCE F. SEATON,[1] LINCOLN, NEB.

Although considerable work has been done toward the use of kerosene as a fuel for internal-combustion engines, there still exists a controversy regarding the correct design of a vaporizing system, and very little work has been done toward determining the distribution of the heat evolved by the fuel. To study these problems the author made a series of tests on a high-speed heavy-duty type of engine using kerosene as a fuel. These tests form the basis of the paper, and the apparatus used and the manner of conducting the tests, are discussed in detail.

At the present time there is a great deal of controversy among the designers of high-speed gas engines regarding the correct design of a vaporizing system to successfully handle kerosene. There has also been very little done in regard to determining the distribution of the heat of the fuel, which is used in high-speed engines. Another idea, which is likewise much disputed, is the effect on the crankcase oil, due to particles of unvaporized fuel passing by the pistons and entering the crankcase, and it was therefore decided to fit up a high-speed engine in such a way that the foregoing conditions could be carefully and accurately studied.

Description of Apparatus

The apparatus used, and upon which these tests were conducted, is shown in Fig. 1. The motor which was tested was a 4½ x 5½-in. high-speed, heavy-duty type and was equipped with a Kingston carburetor connected to a specially designed vaporizer. The exhaust gases were piped directly from the exhaust manifold to the calorimeter. There was also provided a bypass pipe from the top of the exhaust manifold through the vaporizer and back to the calorimeter, and by means of dampers any amount of the exhaust gas could be sent through the bypass making it thus possible to maintain any desired temperature in the vaporizer. Pyrometers were placed both in the bypass and in the main-line exhaust pipes. A thermometer was placed in the intake manifold leading to the motor block. The air leading to the carburetor was maintained at a constant temperature, by means of an electric heater. A manometer was connected to the intake opening into the carburetor, and in this way the suction pressure was measured.

Two Tabor engine indicators were used, one fitted with a 240-lb. spring for measuring the average combustion pressure, and the other with an 80-lb. spring for determining the compression pressure. A Dixie high-tension magneto provided with a starting coupling was used throughout the tests for ignition. A valve was placed in the bottom of the crankcase through which the oil could easily be drained in order that its temperature, gravity and weight might be accurately determined. A water-spray nozzle was located in the intake manifold in order that water might be introduced at high loads to prevent preignition.

The weighing system for the cooling water consisted of two large tanks and a scale, and the water was weighed every fifteen minutes. The fuel was weighed on a specially designed scale connected with a beam-bell contact, which thus made accurate readings possible. Fuel was piped from the fuel drum up to the kerosene tank, the drum being so arranged that air pressure could be used to force the fuel through the pipe into the tank on the scale. At high loads it was necessary to fill the tank between readings, and it was therefore necessary to correct only for the time which it took to fill the tank.

The calorimeter used consisted of a Wheeler surface condenser, the water passing through the tubes and the exhaust gas entering the shell. The exhaust gas thus coming in contact with the cold tubes was brought down to room temperature. Since the products of combustion were condensed in this apparatus, it was necessary to have a valve placed at the point where the gases entered the calorimeter and also one in the large handhole plate. By means of these it was possible to determine the amount of liquid condensed during each run. A gasoline tank, mounted on the side of the dynamometer, was used for starting purposes. A thermometer well was placed in the bypass line near the vaporizer so that the temperatures might be compared with those shown by the pyrometer, also placed in the bypass line.

The load carried by the engine was maintained by means of a Sprague electric dynamometer, and the load was so constant from this source that no governor was used on the engine. It was possible, therefore, to study the force of explosions under constant throttle opening. A water manometer was placed on the exhaust line to determine the back pressure at a point just before entering the calorimeter.

Manner of Conducting Test

The engine was started and brought up to a speed of 1100 r.p.m., the speed recommended by the makers, by means of a load connected to a throttle butterfly valve. The load was then put on the engine by means of the dynamometer. A series of tests was first run with various temperatures in the vaporizer, air entering the carburetor at a constant temperature. The temperature of the intake air was maintained at 115 deg. fahr. and the temperature around the vaporizer was increased from an initial 150-deg. by 100-deg. increments until a temperature of 650 deg. was maintained on the bypass pyrometer. This corresponds to a temperature of 785 deg. in the vaporizer, and in order to obtain this condition it was necessary to shunt all the gases through the bypass at low loads. The loads carried under this condition were approximately 5, 10, 15 and 20 hp. The length of test run on each load was two hours. These series of tests are known as tests 1, 2, 3, 4, 5 and 6, and the average results of tests 1, 3 and 5 for loads of 0, 5, 10 and 20 hp. are given in Table 1, which will be found in the complete paper.

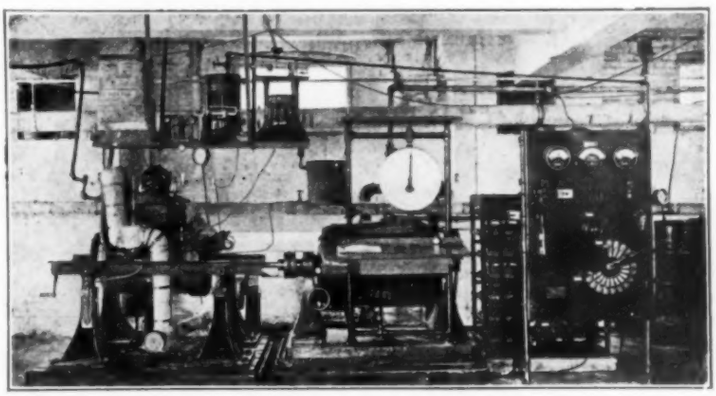

Fig. 1 Apparatus Used in Conducting the Tests

Tests were also made increasing the temperature of the intake air by increments of 10 deg.; that is, the first test was run maintaining a temperature of 650 deg. on the bypass pyrometer and 125 deg. on the intake air. This test is known as E-1. The next test, with a constant temperature in the vaporizer, and another

[1] Prod. Mgr. Hibb Motor Company, Lincoln, Neb. Mem.Am.Soc.M.E.

For presentation at the Annual Meeting, New York, December 1919, of The American Society of Mechanical Engineers. The paper is here printed in abstract form, and advance copies of the complete paper may be obtained gratis upon application. All papers are subject to revision.

10-deg. rise in the intake air, is known as test E-2. This process was continued until a maximum was obtained at which it was thought practicable to run the engine, according to both the amount of power obtained from the engine and to the fuel consumption per hp. The average result of these tests will also be found in Table 1 of the complete paper.

At the end of the series of E tests, which was thought to cover all conditions commonly met in practice, it was decided to run a test in which the limit of the apparatus was reached as far as furnishing heat to the mixture was concerned. This test is known as Test F. All heat from the exhaust gases was thrown through the vaporizer and all possible current was passed through the heating coils in the air-heater. Indicator cards were taken at 15-min. intervals in order that the combustion pressure might be ascertained and also to determine the evenness with which the fuel was burning in the cylinder. The indicator drum was not connected to the engine but simply turned by hand, leaving the indicator cock open. The pressure of successive explosions was clearly shown at the end of each test,

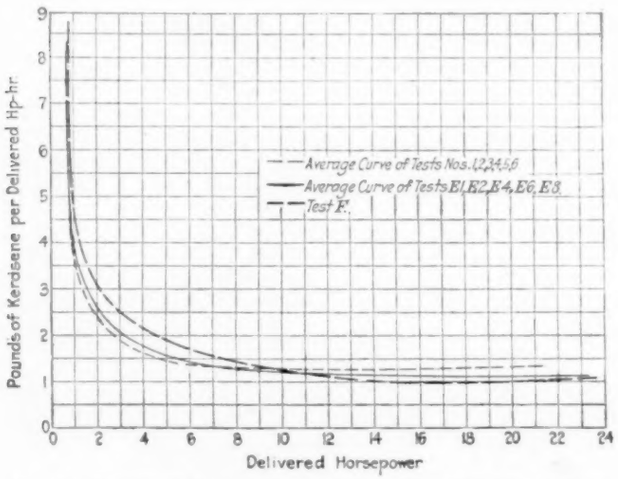
Pounds of Kerosene per Delivered Hp-hr
Delivered Horsepower
Average Curve of Tests Nos. 1,2,3,4,5,6
Average Curve of Tests E1, E2, E4, E6, E8
Test F.

FIG. 2 CURVES OF DELIVERED HORSEPOWER VS. POUNDS OF FUEL

when the spark plug was short-circuited and a light spring used to determine the compression pressure. The oil was cleaned out of the crankcase at the end of each run, when the temperature, gravity and weight were determined. This was done in order that some definite information might be obtained as to the effect of kerosene on the lubricating oil, especially when run without sufficient heat to more or less perfectly vaporize the fuel.

RESULTS OF TESTS

From the summary of results and from the curves plotted between delivered hp. and lb. of kerosene per hp-hr., as shown in Fig. 2, it will be seen that the thermal efficiency of the engine was practically constant throughout all heat changes made as previously described. It will be observed, however, that the motor became much more flexible, especially when the temperature of the ingoing air was raised, as this in turn raised the temperature of the ingoing gas materially, much more, in fact, than was possible by increasing the temperature in the vaporizer, for the reason that a small area was exposed to the hot gases in the vaporizer. It was found that at low heats the motor would not idle down below 800 or 900 r.p.m. At the exceptionally high temperatures of the ingoing gases—about 375 deg.—it was found that the engine could be idled down to 150 r.p.m., and would pick up almost as well as when burning gasoline, and that the engine could be started on kerosene.

Since the fuel-consumption curves shown in Fig. 2 are practically identical throughout the conditions covered in these tests, it seems probable that about the same percentage of the fuel was burned in the cylinders under all the conditions covered in the test. This is also substantiated by the fact that the amount of kerosene deposited in the crankcase was practically constant for all conditions. The only advantage in heating the ingoing air and gas was that it made the motor more flexible. In fact, when the engine was kept up to speed it was found that a greater horsepower could be developed when a low temperature of gas was taken into the cylinders. It seemed quite evident that during all these tests a wet mixture was taken into the cylinders, and that in no case was the kerosene thoroughly vaporized before entering.

It was also observed that at any time during the test of higher heat conditions the engine could be made to preignite by lowering the temperature of the air entering the carburetor. A reasonable explanation of this seems to be that in the cracking process of the fuel a gas is formed which is quite explosive, and that when the conditions are slightly changed this explosive gas is not formed, which does away with preignition; it being fair to assume that this explosive gas, which probably is acetylene, is ignited instantly by the spark which in ordinary practice occurs several degrees before dead center.

The curves of Fig. 3 represent a typical heat distribution throughout the motor, and it will be observed that the maximum thermal efficiency is about thirteen per cent. The percentage of heat going to the cooling water slightly decreases after the load increases; while the percentage of heat to the exhaust gases increases after the load increases. It will also be observed that the

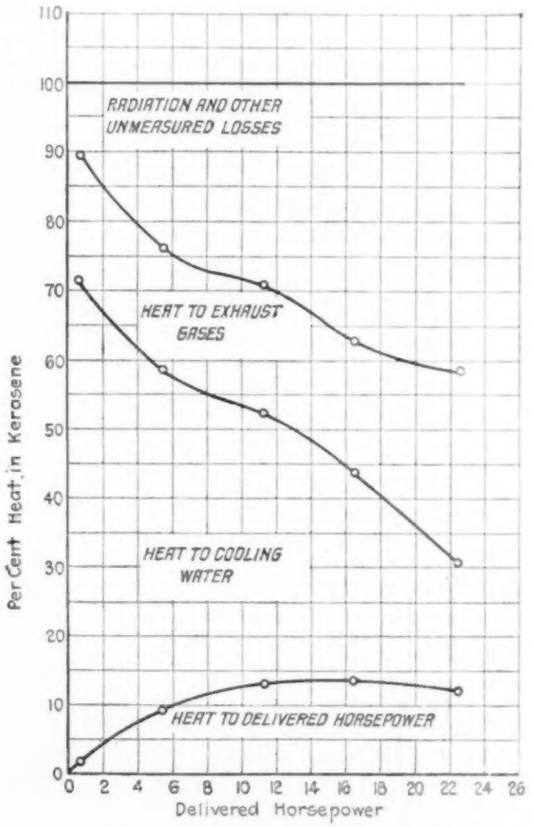
Per Cent Heat in Kerosene
Delivered Horsepower
RADIATION AND OTHER UNMEASURED LOSSES
HEAT TO EXHAUST GASES
HEAT TO COOLING WATER
HEAT TO DELIVERED HORSEPOWER

FIG. 3 A TYPICAL HEAT BALANCE

percentage of heat dissipated through radiation and other unmeasured losses, which includes the amount of fuel deposited in the crankcase, increases as the load increases. This, no doubt, accounts for the increase of unmeasured losses as the load increases.

It is the belief of the writer that a motor designed as follows would handle kerosene at all loads successfully: The piston displacement should be greater per horsepower than that commonly used, a higher compression pressure should be obtained, the intake passages should be large and short, and the intake gas should be heated to a temperature considerably above the boiling point of kerosene. This probably would be done with the exhaust gases, necessitating an automatic temperature control at all loads.

Oil Pipe Lines

By S. A. SULENTIC,[1] ELDORADO, KAN.

In this paper the author compares the cost of pipe-line transportation with that of rail and canal and shows the advantages of the oil engine as a means of economically transporting oil for long distances through pipes. He also derives simple formulae for calculating the pressure, net horsepower and brake horsepower necessary for the transmission of any quantity of oil per day through a pipe of known diameter.

THE cheapest method of overland transportation of oil is by pipe line. The cost in comparison to rail transportation is low, and yet when the rail cost is based on every-day practices, the amount seems very small. For instance, the management of an eastern railway, wishing to impress upon its clerical employees the importance of economy, posted the following notice: "For every lead pencil you waste we have to haul one ton of freight one mile." The cost of a pencil has always been regarded as being insignificant, but when it is considered that it is equivalent to the cost of the above-mentioned haul, a similar comparison with pipe-line transportation should be interesting. The carrying of one ton of freight for one mile at the cost of a lead pencil is very cheap transportation, one or two cents per ton-mile being a low rate. Canal transportation, after allowing for the proper fixed and maintenance charges, may be lower than the rail charges by 60 per cent or more. Five or six cents per mile is not an uncommon charge.

In order to make a very crude estimate of the cost of transporting oil by pipe line when using equipment of the highest economy, assume a single line operating under the following conditions at a load factor of 80 per cent for 300 days per year:

Size of line	8 in.
Length of line	33 miles
Pressure in line	700 lb. per sq. in.
Rate of discharge	900 bbl. per hr.

At this rate the discharge would be 21,600 bbl. per day or 6,480,000 bbl. per year of 300 days. Assuming 6.5 bbl. per ton, the yearly discharge would approximate 1,000,000 tons. The work equivalent of this discharge would be 33,000,000 ton-miles, calling for the continuous expenditure of 257 hp. Assuming the mechanical efficiency of the engine to be 75 per cent, the actual horsepower necessary to install would be 342.

The assumed costs would be as follows:

Line: 33 miles at $1.65 per ft.	$287,500
Right of way at $0.25 per rod	2,640
Freight: 79 cars at $250	19,750
Haulage: 900 tons at $14.50	13,050
Laying pipe at $0.075 per ft.	13,060
Burying pipe at $0.20 per ft.	34,850
Engines, pumps, installed accessories	68,500
Pump stations, buildings and foundations	30,000
Tanks { 2 — 55,000-bbl. at $18,500 each	37,000
Tanks { 2 — 500-bbl. at $500 each	1,000
Telegraph line: 33 miles at $550	18,150
Superintendence	2,500
Incidentals	6,000
Total	$534,000

The operating expense, including fixed charges based on the total assumed costs, would be as follows:

Interest at 6 per cent	$32,040
Depreciation at 5 per cent	26,700
Administration	10,000
Attendance at pump stations and lines	11,500
Repairs to equipment, lines, etc.	4,000
Fuel for pumping — 3000 bbl. at $2.65	7,950
Total	$92,190

[1] Supv. Eng. Empire Gas and Fuel Company. Mem. Am. Soc. M. E.

For presentation at the Annual Meeting, New York, December 1919, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS. The paper is here printed in abstract form and advance copies of the complete paper may be obtained gratis upon application. All papers are subject to revision.

The cost of operation per ton-mile under the assumed conditions would therefore be: 92,190 ÷ 33,000,000 = $0.0028. And as the relation between the cost of pipe-line transportation and rail transportation is in the ratio of 1 to 10, it is easily seen that the waste of a lead pencil in a pipe-line enterprise would be the equivalent of the cost of transporting 10 tons of oil one mile.

It should be noted, however, that almost all of the pipe-line costs are fixed and are mainly independent of the amount of oil pumped. As a result, the transportation cost per ton-mile will vary almost inversely with the load factor of the line. If this hypothetical pipe line should be operated only one-tenth of the time assumed, the unit transportation cost would equal the rail cost. Furthermore, these figures are based on a life of 20 years (5 per cent amortization). A railroad would probably be used for various classes of freight as long as it existed, but a pipe line is of service only as long as oil is presented for transportation. If the pipe line in question were to become obsolete in ten years through the exhaustion of the oil fields or other causes, the ton-mile cost would be greatly increased.

In this connection it may be of interest to give a few figures and examples showing the relations existing between pressure, capacity, diameter, length of line and power required.

Disregarding viscosity, the general hydraulic formula for friction head in a pipe discharging an uniform volume is

$$F = k \frac{v^2 L}{2gD} \quad \ldots\ldots [1]$$

in which

F = friction head in feet of water, lb. per sq. in. ÷ 0.433
k = friction coefficient for 38 gravity oil = 0.024
v = velocity of flow, ft. per sec.
g = acceleration of gravity = 32.2 ft. per sec.^{2}
L = length of line, ft.
D = diameter of line, ft.

The formula for pressure in the line may be stated as

$$P = 0.433\, k \frac{v^2 L}{2gD} \quad \ldots\ldots [2]$$

in which P = pressure in line in lb. per sq. in.

The discharge Q of the line, cu. ft, per sec. can be easily derived and stated as

$$Q = \pi \frac{D^2 v}{4} \quad \ldots\ldots [3]$$

in which Q varies directly as v. Since P varies directly as v^2 in Formula [2] and Q varies directly as v in Formula [3], it follows that P varies directly as Q^2.

The net horsepower required for a pipe line may be most readily calculated if we note that the pressure per square foot is equal to the number of foot-pounds required to displace 1 cu. ft. of oil, or

$$\text{Hp.} = \frac{144\, PQ}{550} \quad \ldots\ldots [4]$$

For 1000 bbl. per day against a pressure of 1000 lb. per sq. in., the net hp. necesary by Formula [4] would be

$$\text{Hp.} = \frac{144 \times 1000}{550} \times \frac{1000 \times 5.61}{24 \times 60 \times 60} = 17$$

where 5.61 = cu. ft. per bbl.

Assuming a pump efficiency of 85 per cent, the horsepower of the engine would be 20. Here we have a very simple rule for calculating the horsepower from bbl. per day and pressure in lb. per sq. in.; namely,

(*Continued on page 914*)

Industrial Unrest

Problems Relating to Present Industrial Conditions Discussed by Two Leading Authorities on Economics and Sociology

Industrial Unrest has been the subject of two addresses recently delivered before the New York Section of The American Society of Mechanical Engineers. On the evening of September 17, Dr. William M. Leiserson, formerly Chief, Division of Labor Administration, Working Conditions Service, U. S. Department of Labor, outlined the history of industrial unrest, and in the course of his address described the various classes of strikes. At a meeting on October 9, Dr. Henry R. Seager, professor of political economy at Columbia University, discussed the subject more especially from the viewpoint of the employee. Summaries of the two papers follow.

INDUSTRIAL UNREST

By DR. WILLIAM M. LEISERSON

THE industrial unrest of today may be better understood by a study of the important facts concerning its growth. The labor problem is more than an industrial and economic problem, it is a social and political problem. We should not isolate such questions as strikes, production, closed shop, collective bargaining, unrest and Bolshevism, but should study the background and history of the labor problem, the character of the people that are restless, the different problems of industry from every point of view and obtain, if possible, a bird's-eye view of the whole problem, from the time when industrial unrest first began to appear to the present day.

The labor problem is a problem of controlling our great masses of individuals to a common purpose. It has always been argued that the mass is too ignorant to be capable of rising to a higher level. This principle was followed in the early centuries when society was held together by religious leaders who issued the orders of the priests and popes to the common mass. But however ignorant the majority may have been, there were some who rose out of the mass with a new purpose and led them to religious democracy.

Political democracy was the next big question. Kings and nobles and people with political power issued laws and orders through established forms. The ordinary common man was not expected to know anything about government. But here again, contrary to the expectations of those on the higher level, the mass rose, demanded some share in the government and won the right to vote.

"And now," to quote Dr. Leiserson, "that great mass of rank and file insists, 'We must have a say in the government, in the management of the industries in which we spend our lives.' You can say from now until doomsday that they don't know anything about industry. Well, they didn't know anything about government or religion. Certainly they knew very much less about government and religion than they know about industry, because they, at least, work in industry. And they now insist on a voice in the management of industry."

We can no longer argue that the mass is ignorant. The group of people who have held that the common people will always remain where they are is gradually giving way to two other groups; one of these believes that unless the whole mass rise at once the problem cannot be solved; the other group sees what is really happening, the gradual rise, stratum by stratum, of the working people. Dr. Leiserson illustrated this by referring to the rise and fall of prices.

"In the United States this industrial situation that you have today has repeated itself at least half a dozen times — the same sort of unrest, the same sort of thought that we are having now. We have had periods in the history of the country when proportionately we had more strikes than we have today. At every period of rising prices in the history of this country there have been great numbers of strikes, great numbers of rebellious movements among working people. In the History of Labor in the United States by Professor Tolman you will find a chart which really represents the backbone of the industrial question. It shows our prices rising, falling; rising, falling; rising, falling. And about 1819 there was a period of rising prices, and our first real labor movement began then. From 1827 to 1837 we had a very remarkable rise in prices. You remember that was the time of the wild-cat banks: and during that time we had a national labor organization in this country, back in 1837, and proportionately at that time there were probably as many union men, as many organized labor unions, in 1837, to the number of wage earners, as there are now. And particularly from 1835 to 1837, you had this remarkable number of strikes, and you had a workman's party at that time. And then from 1837 down to almost 1850 we had one of the longest industrial depressions that this country has ever known. The bottom seemed to have fallen out of society. And you had very little in the way of a labor movement at that time. From 1850 to 1855 prices went up again. In came the labor movement again, union. Then the slavery question knocked everything out, and the war came on, and prices went up, and you had labor unions and strikes and wage earners trying to get control of industry just the same as today; and after 1870 there was again a period of depression; and today this enormous rise in prices, in cost of living, is what is causing all your trouble, just the same as it did before."

Dr. Leiserson went on to analyze this situation. A rise in the cost of living affects the standard of living of the workingman. Then comes danger, not from the very poor, those on the starvation line, who have nothing to lose, but from those somewhat higher up, who have gotten used to a higher standard of living and do not want to give up what they have gained. During times of falling prices there is a great deal of talk of socialism or communism, such as the great socialistic movement from 1837 to 1842. But when prices are rising the workmen say, "Our standard of living is threatened and we must have more." This, it would seem, is the opportune time for the wage earner to improve his condition.

The character of these movements of the working people to better their conditions, to get a larger share in the products of industry, depends upon the character of the people who are the wage earners. Pure Americans made one kind of demands, Irish- and German-Americans another, and today Polish and Jewish and Italian and other European elements are making a different kind of a demand, and the problems are different. The first labor unrest in this country, for instance, was a political question. The situation was similar to that of today, except that the chief demand of the workmen in 1837 was the right of unpropertied people to vote. Later, after the Civil War, wage earners fought against the introduction of machinery. Then employers brought rural Americans into the cities rather than grant the demands of the organizing workmen. These, in turn, organized and employers brought in immigrants to take their places. And now it is this foreign element, introduced at the time of the great strike in Homestead, in 1882, and a big steel strike in the 90's, that is organized and striking that it may maintain the standard of living which it has adopted in America.

Keeping this general history of the labor problem in mind, it is possible to analyze the strikes which are a result of the industrial unrest of today. Their character is more important than their number.

The largest number of strikes, numerically, are unorganized

strikes. The strikers are unorganized bands of dissatisfied working people. In a typical strike of this class, the majority of the strikers were foreign born, ignorant and dissatisfied with their wages. The firm had no dealings with unions and professed to be of the open-shop type. But it had kept its employees in ignorance as to how to express their grievances. Without any organization or financial support, without any definitely formed demands, they revolted. They could not obtain the support of a union because they were not organized, and for the same reason their demands, later presented to the firm through a committee led by a young foreigner, were rejected. The strike gradually died out, the employees losing their immediate demands but gaining a knowledge of the value of organization.

The second type of unorganized strike is that of people never organized before, but just coming into an organization, the strike of federal employees, of teachers, of policemen, of firemen, etc. Their demand is the usual one; they want sufficient wages to maintain their standard of living. But have these people, who have obligations to the public, the right to organize and to strike? Should they affiliate with the American Federation of Labor? On this subject Dr. Leiserson said: "Personally I think the public is not ready to let them affiliate with the American Federation of Labor. But I think the public is wrong. It is exactly the same situation as when the people who were serving in the armies of the king said, 'We want the right to vote, to elect members of Parliament,' and so forth, and they said, 'For heaven's sake if you can vote, why, you would control the army, and you are the fellows that serve in the army.' But we fought it out. We vote. People who serve in the army vote and control the army. People who work for the Government vote. Society is not broken up on account of it, is it? Why? Because we are reasonable human beings. A union is not organized to strike. A union is organized to deal collectively with the employer, whether it be public or private, and if the employer will deal with it, why, there needn't be any strike. It is just a question of talking with the men, and conferring, and when they cannot agree, to put it up to an arbitration of some kind. We do it on the railroads. We do it in other industries. We do it in an industry with which I happen to be connected now, the clothing industry, where the employees agreed not to strike provided the employer will hear their case, and provided, further, that if they cannot agree, there will be a judge to decide who is right."

There is a third kind of unorganized strike which is just appearing, that of the clerical employees. The rising cost of living is also threatening their standard of living, and the time is not far distant when their growing dissatisfaction will result in organization and strikes.

On the other hand we have the organized strikes, guided by trade unions. The members of these unions are skilled workmen, men who have been organized for some time, and have very definite ideas of what they want. The American Federation of Labor has not organized the immigrant class which is found in many industries, but in the packing and steel industries it has been steadily working toward organization. In the packing industries a mediator was appointed by the War Department during the war, and difficulties are adjusted through him. In the steel industry, however, the corporations would have no dealings with unions. During the war they handled the situation by paying such high wages for overtime that there were no strikes. Now the American Federation of Labor has organized the employees of the steel industry, both foreigners and American, and because the corporation still holds to its position, a strike is imminent.

The main point of difference is this: The employees, through the union, want collective bargaining. The corporations avoid the issue by professing to want the open shop, which is not, as they conduct it, a fair partnership. Their statement is this: "If any man who has a grievance will come to us and tell us about it, we will fix it up; and if we don't, he is perfectly free to go somewhere else." They give the employee the choice of the little piece or none. When the corporation finds that the open-shop method is dangerous to its interests it declares the closed shop. It will not deal with unions, but when its own methods fails it is quick to adopt the tactics of the union. It also attempts to avoid collective bargaining by maintaining that the members of the unions and the employees who strike are not Americans, but are ignorant foreigners. In the organized strike Americans as well as foreigners take part.

"Do something to keep these side issues out of the industrial question," urged Dr. Leiserson. "The big thing that is up today in this country is the demand for collective bargaining. It comes in asking more wages, or firing a foreman, or a closed shop, or shorter hours, or something of that kind. Those are the immediate demands. But the important thing is collective bargaining, the right to sit down with the employer, to send a business agent, a lawyer, or whatever you want to call him, a man who knows how to bargain, if it is an ignorant foreigner, and to say to the employer, 'Here is our labor. You want to buy it. We want to talk business with you. You can't have it all your own way, and we will tell you how many hours we are going to work and what we are willing to take for it and so forth.' That is democracy. That is Americanism. That is the issue that has to be fought out now."

The revolutionary strikes are not the dangerous kind. The radical element draws a crowd but seldom gains its demands. "The real danger is when an organization that is strong makes conservative demands and is able to back them up, conservative demands such as the railroad brotherhoods have made; perfectly legitimate and legal." In the case of the railroad brotherhoods and also in the case of miners and others, they have gradually improved their condition to the point that they endanger industry. The railroads, for instance, cannot afford to pay the wages that the railroad brotherhoods are able to get. The only thing left for them to do is to improve their own condition by cutting out the capitalist and turning the railroads over to the Government.

This improvement in the condition of employee to the point where he proposes government ownership of industries is the real revolutionary thing in the industrial situation today. The railroads are in the hands of the Government. The mine workers have already passed a resolution for the government ownership of mines. The working people keep raising their standard of living, and if industry cannot support them on the high plane that they want, it must be revolutionized. This effective, conservative action, looking toward progress, is dangerous to the existing controllers of industry, and its advocates cannot be treated as Bolshevists or Socialists.

"The American Federation of Labor is growing stronger, because it is based upon the important principle of collective bargaining, which is the way we are going to get democracy in industry. Nobody has yet shown us any other way. Employers have said, 'We will have copartnership, profit sharing; workmen will be put on boards of directors.' That is not democracy. That is taking a fellow out of the working class and putting him into the capitalist class. Democracy means taking working people and letting them from day to day practice democracy, vote in industry, make decisions. You won't have any class spirit when the workman, as a workman, will be able to vote. We do not class people politically any more because the commonest man can vote. We won't have any industrial classes when the commonest man can decide, 'I will work so long; I will get so much!' He won't always get his way, any more than when you vote you get your way; but the majority will rule."

Today the radical opposition to the Federation of Labor has given place to a more conservative opposition. On both the labor side and the employers' side a new kind of unionism is challenging the Federation. The new unions, the labor union and the company union, are similar in their principles to the Federation and, therefore, especially dangerous to it. Each one, to some degree, is working for collective bargaining. If collective bargaining is going to succeed it ought to be centered in one organization. If the American Federation of Labor is to be this central organization it needs to improve its own efficiency, for some labor unions are in many ways superior to it. It must be able to understand this gradual uplift of the working people, satisfy their constantly increasing demands and help them maintain their standard of living without jeopardizing industry.

THE HUMAN FACTOR IN THE OPERATION OF INDUSTRY

By DR. HENRY R. SEAGER

DURING the war every country demonstrated that there was latent in its industrial population productive power of a volume that had not been imagined. Wherever it was possible to substitute for the ordinary productive-wages motive, the motive of desiring to do one's utmost to win the war, the productive result was amazing. The armistice had hardly been signed, however, when labor troubles began to prevent production equal even to that before the war.

The key to the solution of the labor problem, as it appears to Dr. Seager, is found in his statement: "The problem in essence is to try to carry over into the period of peace that lies before us some small part of that eager coöperation that we had between employer and employee in some of our munitions plants and in some of our other big producing plants while the war was going on, when both sides for the time being forgot their differences and threw themselves into the work of production."

Dr. Seager outlined *four* ways of handling the labor problem that are currently being tried. One of them is the method of the just and generous small employer, an illustration being found in the case of Mr. Endicott, a shoe manufacturer. Mr. Endicott states that the secret of his immunity from labor troubles for some 35 years is that he always met any one who wanted to see him, whether a labor organizer, or whoever he might be, and that he always tried, not only to keep in touch with the needs of his employees, but to anticipate their needs before they arose. But this method used by Mr. Endicott and also by Mr. Ford is applicable only to a limited range of industries; and, moreover, every employer in an industry cannot do better by his employees than every other employer, as is the case with Mr. Endicott and Mr. Ford in their particularly well-organized industries.

A second method that is being tried in a great many different ways and detail is the method of the giant corporations like the Steel Trust, which tries by means of welfare workers and by means of profit sharing to content its employees and discourage them from going in labor organizations. From a hardheaded business point of view this method has had much to commend it, but when the problem is studied from the point of view of the employee, we find that the wage earners consider welfare work and profit sharing as the tender of a mess of pottage in exchange for the best life of a free-born citizen in a free country. It does not develop loyalty to the employing corporation, because the employees feel that they are being bought, being deterred from doing something that they think they ought to have a perfect right to do, that is, belong to a labor organization and deal with the employer through representatives.

A third method, a method that is receiving a great deal of discussion at the present time, is the method of the shop committee. One employer told Dr. Seager that he had developed this method in his plant to a point where he believed he could leave even the determination of wages to the shop committee. He explained that he laid before the committee all the facts in reference to his business, and that as they were put in a position of responsibility for deciding all questions in the light of the facts, he could depend on their deciding them fairly. But the experience of this employer was possible only because it was a small-scale and rather simple business, employing rather high-class employees.

A fourth plan that is also beginning to receive a great deal of attention, more in the United Kingdom than in this country, is the plan of joint industrial councils. Up to the present time some 75 of the important industries of the United Kingdom have organized these joint industrial councils. In these industries labor and employers were already well organized, and were in the habit of dealing together. They organized this joint organization or council in which both sides are equally represented, which discusses the important problems of the industry that concerns the wage earner, and discusses it, not merely for a single plant, but for the whole industry. Underlying these joint industrial councils are shop committees or works committees, as they call them in England, and district councils, which bring together the representatives of the employers and the employees in the districts.

Of these four plans the last two have been developed on the basis of an attempt to understand the wage earner's point of view and to take account of his desire to have some share in determining the conditions under which he is to work. They differ from the plan of the Steel Corporation, in recognizing the right of the employees to organize and encouraging them to organize. They differ from the method of dealing with the labor organizations as they have been organized in this country, in that at the basis of them is an organization of the employees of the plant, shop committee or works committee, with negotiations between the shop committee and the representatives of the employer in the plant deciding as many issues as possible. Only issues that cannot be decided within the plant are carried up, as it is worked out in England, to a district council, which represents the industry a little more broadly, and only those which the district council cannot decide are carried up still higher to the joint industrial councils, representing the whole country.

We have passed away from the condition of small-scale production and entered a period in which production through giant corporations is becoming more and more the characteristic method of production. Along with that is lost inevitably the contact between the employer and the employee, as in the case of the Steel Corporation. The capital is provided by stockholders, and the business is controlled through a board of directors, which functions through smaller committees made up of men of large financial and business interests. These men naturally live in the financial centers of the country while the industry, on the other hand, is located in the industrial centers. Personal contact between the employer and the employee is out of the question.

There is no doubt of the economic advantages of an organization like the United States Steel Corporation, but such a corporation cannot follow the methods of Mr. Endicott and Mr. Ford. In considering these different plans, this new situation of the giant corporation dealing necessarily at long range with its employees must be kept in mind.

The qualities that, under these new conditions, an employer should have to deal successfully with the labor problem are, first of all, persistent good-will—an attitude of good-will toward his employees that will inspire them with confidence. If they feel that he is trying to get the better of them, their reaction can be counted upon with certainty. They will try to get the better of him at every point. Second, insistence on square dealing. There is nothing that the wage earner is so responsive to, one way or the other, as fair dealing. Third, a sympathetic understanding of the point of view of the employee. The real employer has good-will toward his men, and square dealing is very, very common. But on the third qualification, a sympathetic understanding of the point of view of the employee, of his legitimate desires and his aspirations, employers very often fall down. They very often fail to see the thing from the employee's point of view.

It is also important to consider what are the reasonable demands and legitimate aspirations of the employees. An advertisement for employees summarizes these as: "First, good pay with opportunity for advancement; second, reasonable hours with frequent resting periods; third, safeguards for health; fourth, ample provision for comfort and convenience; fifth, association with other worth-while people; sixth, protection against financial loss in case of sickness or accident; seventh, work that holds the worker's interest all the time." The last-named demand Dr. Seager believes to be the crux of the difficulty and the underlying motive of the different plans discussed. Holding the interest of the worker was the secret of the success of some of our war industries. The work itself was the same old work, divided more than before in many cases, but a tremendous interest was given it because every worker felt that he was working to do his bit for his country, to help win the war. From this point of view, Dr. Seager elaborates these four methods and speaks of others. He discusses several systems of paying wages, of which a most common one is the day-wage system.

Everybody who has had experience with employment feels that

the day wage ought to be about the last resort from the point of view of giving an employee an interest in his work. By itself it almost completely fails to accomplish the purpose, because, under this system, the employee is only too apt to be watching the clock and eager to get away from the factory as soon as the day's labor is over. To give a little stronger incentive, the piece-wage system is tried in many situations. It cannot be tried very generally, because the number of employments to which it is applicable is limited. Some of the difficulties of the piece-rate system were met in the shipbuilding industry during the war. The output was held down for two reasons, the fear that the piece worker would go beyond the limit of his endurance and the conviction of the employee that with increased production would come a cut in rates.

A more refined method of trying to give the worker a certain interest in his work is the premium or bonus plan, which in practice more often than not antagonizes the wage earner and therefore misses the result that it is intended to accomplish. Another plan that is being urged very strongly is profit sharing, which has very great merit in certain industries under certain conditions; but when applied to a large complex industry it largely fails of its purpose all by itself, because the small dribble of profits that goes to the individual wage earner is not enough to give him any special inducement to work better. His share of the profits is almost negligible. Moreover, the worker is intelligent enough to know that whether he works hard or not, the profits will be about the same. As an individual he is not going to effect the result very much; and so the more intelligent he is the less likely he is to respond. A group response cannot be obtained by promising a number of different people a small return if the whole group works together, for there will always be a number of people who will let some one else take the extra burden, reasoning that it will not make much difference to the result whether he works harder or not. A different system of representation is necessary if the employee is to be stimulated to make the right sort of response, if he is made to feel that he is coöperating with the employer in trying to turn out the largest volume of profits, so that he may have as his proportion a larger share as well as the employer. Recognition of the union and collective bargaining is a plan which Dr. Seager believes must be worked out. Organized labor unions tend to divert attention from the productive problem, which is after all the fundamental problem, to the problem of sharing the return of the industry. A plan of organization is needed that will bring home to every employee the fact that on his efforts depends the share that he is going to receive, and if he does not do what he can toward production, then he is bound to lose when it comes to distribution. Under the forms of labor organizations that are developed in this country the notion that there is only a certain amount of work to be done, is all too prevalent.

Dr. Seager said that from the point of view of the possibility of increasing the interest of the employee in his work, the shop-committee plan and the joint industrial plan contain this possibility as the other plans do on the same scale. The shop-committee plan is a plan that recognizes the desire of the employee to have sub-contracts with the larger aspects of the industry, to get out of his particular monotonous job into an appreciation of the higher aspects of the industry, so that he may feel that he has some part in the larger aspects, not in managing the industry exactly, but in understanding it, and seeing its relations to other industries. The employer who objects to this plan on the ground that the employee should not be given a share in the management of the business, looks at it from the wrong point of view. This shop-committee plan interests the employee in the larger aspects of the business. The thing that comes to the surface in almost every dispute is that the wage earners have little or no appreciation of the limitations that surround the employer. The shop-committee plan gives them a wider view of the problem and some insight into the employer's situation. The more they can be taught about the problem that confronts the employer, the more modest their demands will be and the greater their insight into these broad problems of industry.

A necessary accompaniment of the shop-committee plan is the development on the basis of shop committees of district councils and of joint national councils, because after all one plant cannot decide what wages would be fair, what hours would be reasonable and what conditions would be right. A more general view must be obtained in dealing with industries like the United States Steel Corporation, that is organized nationally with plants in all parts of the country, and the reasonableness of the wage-earner's demand that he organize nationally and deal collectively with a nationally organized trust like the Steel Trust, must be recognized.

Many people look upon the current labor unrest as the inevitable accompaniment of the readjustment that must go on because of the higher cost of living and other after-the-war conditions, and optimistically believe that after this readjustment this unrest will disappear. But before the war we were on the verge of the most serious series of strikes and the most awful period of industrial unrest in this country that we have ever experienced. The war came and temporarily it diverted attention. But no sooner was the armistice signed that the unrest began again on a scale greater than we had experienced before the war, and while much of it is due to necessary readjustments, a large part of it is due to a growing dissatisfaction on the part of the wage earner with our present system of industrial organization.

That new spirit, as it has been called, is brought out very strikingly in the sort of demands that are made prominent by representative groups of wage earners. In the Steel strike, for example, the dissatisfaction is not merely with wages or hours or working conditions, but fundamentally it is a demand for recognition of the union and the right of the men to organize and to deal through their chosen representatives with the Steel Corporation. In connection with the railroad situation, the railroad brotherhoods, who have been among our most conservative labor organizations and among the best led and best behaved, have come out strongly for government ownership of the railroads and management by the employees, the higher officials and the representatives of the lower officials. That represents a revolutionary change in the point of view of the leaders of the brotherhood. Before the war they would very generally have opposed the nationalization of the railways, but there is a new spirit and a new point of view, and their demands and their interests are not centered so much in the wage question or in the hour question.

In the same manner, in the coal-mining industry the United Mine Workers has committed itself to a demand for the nationalization of coal mines, an entirely new development, an entirely new angle. "This reflects," Dr. Seager said, "a state of mind that has come to stay, and not only has come to stay, but is becoming and going to become more influential as time goes on, rather than less influential. It represents a demand on the part of the wage earner for a more important relation to industry."

This change of mind has been brought about in a large degree by war conditions. Labor leaders and wage earners have been appealed to as fellow-citizens doing their part in the war to make the world safe for democracy. They have come in closer contact with the employers and have developed a new ambition and a new confidence in their ability to take a larger share in industry. In the stress of the Civil War Lincoln early sensed the fact that a country could not long exist half slave and half free. This new spirit that is so often referred to is the dawning appreciation of the fact that no more can a country long exist the mass of whose population is industrially subservient and controlled and at the same time be politically free and self-determining, the more one thinks of it the more one realizes that there is an inconsistency. If we can trust these men as fellow-citizens to share, man for man, the responsibilities of maintaining this Government, we have got to recognize the legitimacy of their demand for a larger share in connection with the regulation of industrial affairs.

Dr. Seager concluded with the statement: "For the sake of better relations between employer and employee; for the sake of the larger production that will result from better relations; for the sake of the larger incomes that we all may enjoy as a result of this larger production, and for the sake of preserving our democratic institutions by making our democratic Government not only safe but efficient through the lifting to a higher plane of the intelligence and the ability and the sense of responsibility of the wage earner, I believe we must heed this new spirit and this new attitude."

ENGINEERING RESEARCH

A Department Conducted by the Research Committee of the A. S. M. E.

Classification of Information

TO explain the method of classifying the various notes in the Division of Engineering Research, the classification prepared by the Industrial Research Committee of Engineering Foundation and the National Research Council has been used. Although it has been difficult to bring certain notes under this classification, an endeavor has been made to do so. In looking up a subject the question should be asked: "Under which of the general headings does the subject naturally fall?" It is hoped that this classification will materially aid the readers of MECHANICAL ENGINEERING in finding references.

No.	CLASS	CROSS-REFERENCES
1	Abrasives	Carborundum, Emery, Sandpaper
2	Acids, Alkalies, Salts & Sundries	
3	Agricultural Equipment and Engineering	
4	Air	Air-Driven Machines, Air Products, Compressed Air
5	Aircraft	Aeronautics, Airplanes, Balloons, Dirgibles (See Internal-Combustion Motors)
6	Apparatus and Instruments (Chemical, Physical)	Balances, Compasses, Lenses, Telescopes, Transits, Microscopes
7	Astronomy	
8	Automotive Vehicles and Equipment	
9	Beverages, Non-Alcoholic	
10	Calorimetry, Pyrometry, Thermometry	
11	Cellulose and Paper	Pulp
12	Cement and Other Building Materials	Concrete, Marble, Slate
13	Chemistry, Analytical	
14	Chemistry, Biological	
15	Chemistry, General & Physical	
16	Chemistry, Inorganic	
17	Chemistry, Mineralogical and Geological	
18	Chemistry, Organic	
19	Chemistry, Pharmaceutical	
20	Computing, Recording & Talking Devices	Adding Machines, Phonographs
21	Concentration of Ores	Flotation
22	Dyes and Textile Chemistry	Inks, Pigments
23	Electrical Communication	Cable, Telegraph, Telephone, Wireless
24	Electricity, General	Economics, Insulation, Utilization
25	Electrical Instruments	
26	Electroplating	
27	Electric Power	Conversion, Distribution, Generation, Motors, Transmission
28	Electrochemistry	Electrochemical Processes, Storage Batteries
29	Explosives and Explosions	Dynamite, Power, TNT
30	Fats, Fatty Oils and Soaps	
31	Fire Prevention	Extinguishers, Sprinklers
32	Foods	Bakery, Biscuit, Cold Storage, Preservatives
33	Foundry Equipment, Materials and Methods	Casting, Molding
34	Fuels, Gas, Tar and Coke	Coal, Oil, Peat, Petroleum
35	Fuel Utilization	Boilers, Furnaces, Gas-Producers, Stokers
36	Gases, General	Pneumatics
37	Glass and Ceramics	Bricks, China, Porcelain
38	Heat	Thermal Physics
39	Hydraulics	
40	Illumination (Electric, Gas and Other)	
41	Internal-Combustion Motors	Diesel Engine, Gasoline Engine
42	Iron and Steel	Ferrous Alloys
43	Leather and Glue	
44	Light	Optics
45	Liquors, Fermented and Distilled	Beer and Wine
46	Lubricants	Graphite, Oil, Petroleum
46*a*	Machine Tools	
47	Magnetism	
48	Marine Engineering	
48*a*	Mathematics	
49	Mechanics, General	
50	Metal Manufactures, Miscellaneous	
51	Metallurgy and Metallography	
52	Meteorology	
53	Metrology	
54	Military & Naval Equipment	Ammunition, Armor, Ordnance, Torpedoes, Small Arms
55	Mining, General (Testing Drills, Ropes, Tools, Ore Dressing)	
56	Molecular Physics	
57	Non-Ferrous Metals	Aluminum, Brass, Bronze, Copper, Gold, Platinum, Silver, Tin
57*a*	Oils	
58	Paints, Varnishes and Resins	Dryers, Oil, Pigments, Putty
59	Petroleum, Asphalt and Wood Products	
60	Photography	Cameras, Developers, Films, Moving-Picture Equipment
61	Properties of Engineering Materials	
61*a*	Protective Devices	
61*b*	Pumps	
62	Railroad Rolling Stock and Accessories	Cars, Locomotives
63	Railroad Track and Signals	
64	Refrigeration	
65	Road Materials & Equipment	Highways
66	Rubber & Allied Substances	Guttapercha and Substitutes, Rubber Manufactures
67	Safety Devices (Transportation, Manufactures, Mines)	
68	Soils and Fertilizers	Nitrates, Phosphates
69	Sound	Acoustics
70	Steam Power	Economizers, Engines, Turbines
71	Subatomic Phenomena and Radioactivity	
72	Sugar	Sorghums, Syrups
73	Surgical, Dental and Hospital Equipment	
74	Textile Manufacture and Clothing	Cotton, Linen, Wool
74*a*	Transmission	
75	Water, Sewage and Sanitation	
75*a*	Wastes	
76	Welding	
77	Wood Products (other than Cellulose and Paper)	
78	Ventilation	

Coöperation in Research by the United States Government

In MECHANICAL ENGINEERING for August (p. 691) there appeared a letter outlining the action of the British Government in aiding research. Our own country has taken a similar stand in regard to industrial research and the following letter from the Department of the Interior, Bureau of Mines, briefly outlines the manner in which this coöperative work is at present being carried out.

DEPARTMENT OF THE INTERIOR, BUREAU OF MINES
WASHINGTON, D. C., September 6, 1919

PROF. A. M. GREENE, JR.,
TROY, N. Y.

Dear Sir:

Mr. Bancel calls attention, in the August issue of MECHANICAL ENGINEERING, to the action of the British Government in subsidizing industrial research by the coöperation of Government and private effort. It may be of interest to call attention to a growing practice in coöperation in the Bureau of Mines, Interior Department.

The Bureau is charged with the duty of conducting "inquiries and scientific and technologic investigations concerning mining and the

preparation, treatment and utilization of mineral substances with a view to improving health conditions and increasing safety, efficiency, economic development and conserving resources through the prevention of waste in the mining, quarrying, metallurgical and other mineral industries." There are other organizations having similar aims in part, and it frequently happens that by combining effort there is mutual advantage in increased facilities and output.

During the fiscal year, 1918-1919, the Bureau of Mines had formal coöperative agreements with the following:

University of Arizona, Tucson, Ariz.
University of California, Berkeley, Cal.
Colorado School of Mines, Golden Colo.
University of Idaho, Moscow, Idaho.
State Geological Survey Div. of the State of Illinois, Urbana, Ill.
Engineering Experiment Station of the University of Illinois.
University of Minnesota, Minneapolis, Minn.
Ohio State University, Columbus, Ohio.
Bartlesville, Chamber of Commerce, Bartlesville Okla.
Oregon Bureau of Mines and Geology, Portland, Ore.
University of Washington, Seattle, Wash.
University of Utah, State School of Mines, Salt Lake City, Utah.
Pope-Shenon Mining Company, Salt Lake City, Utah.
Shannon Copper Company, Clifton and Tucson, Ariz.
Ocotillo Products Company, Indianapolis, Ind.
Sinclair Refining Company, Chicago, Ill.
Mid-West Refining Company and Ohio Oil Company, Denver, Colo.
J. B. Jenson, Salt Lake City, Utah.
Iron Mountain Alloy Company, Colo.

The kind of coöperation varied widely. In several cases the Bureau furnished technical direction and no funds, in other cases both parties furnished technical men and funds; altogether, the financial obligations were in excess of $350,000, about $200,000 being furnished by the Government.

Very truly yours,

(Signed) O. P. Hood,
Acting Director.

A—Research Results

The purpose of this section of Engineering Research is to give the origin of research information which has been completed, to give a résumé of research results with formulæ or curves where such may be readily given, and to report results of non-extensive researches which in the opinion of the investigators do not warrant a paper.

Apparatus and Instruments A13-19 Continuous Helium Recorder. The Bureau of Standards has installed an apparatus at Petrolia, Tex., which records continuously the amount of helium present in the natural gas. Bureau of Standards, Washington, D. C. Address S. W. Stratton, Director.

Apparatus and Instruments A14-19 Tests on the Constancy of Precision Gages and End Standards. In examining several thousand gages remarkable constancy was found. Gages of 2, 3 and 4 in. changed from two to six-thousandths of an inch in a few months. To find the immediate effect of large temperature changes several gages were cooled in liquid air and then brought back to 20 deg. cent. Some returned to their original length within a few millionths of an inch, but one 3-in. gage was found to be 0.0022 in longer and a 4-in. gage 0.0023 in. longer after the treatment. Several were heated to a higher temperature and allowed to cool to 20 deg. cent. One 2-in. gage which had been heated to 110 deg. cent. was found to be 0.0002 in. longer, and a 4-in. gage heated to 200 deg. cent. was 0.0017 in. shorter after being carried through the temperature cycle. It seems probable that strains must have existed in the material which were relieved by the large changes in temperature. A permanent material is sought for by the Metallurgical Division of the Bureau of Standards. Various types of heat treatment are being proposed. Bureau of Standards, Washington, D. C. Address S. W. Stratton, Director.

Apparatus and Instruments A15-19 Thermal Expansion. The linear thermal expansion coefficients of a large number of gages has been found to vary from 11 x 10^{-6} to 13 x 10^{-6} per deg. cent. It is necessary therefore to use gages at the temperature at which they have been calibrated. Bureau of Standards, Washington, D. C. Address S. W. Stratton, Director.

Apparatus and Instruments A16-19 Contact Gages. The forces necessary to separate contact gages is 25 to 35 lb. per sq. in. in using ordinary finish. With high optical polish and tested for planeness by the optical method of interference, 100 lb. per sq. in. was required. The separating film between gages brought carefully into contact is less than two-millionths of an inch. Bureau of Standards, Washington, D. C. Address S. W. Stratton, Director.

Boilers and Accessories A2-19 Chimneys. Stack Performance. Experiments on Stack at Johns Hopkins University showed that resistance thermometers would change in readings due to exposure to flue gases. Copper and copper-constantin couples were used with success. There were variations of 5 to 10 deg. fahr. in temperature across a given section. The drop in temperature in 130 ft. varied from 71 to 118 deg. fahr., as shown by table. The velocity of hot gas varied from 5 to 40 ft. per sec. and could not be read by pitot tubes using differential gages. Much leakage of air occurred in system. 10 per cent CO_2 in boilers was reduced to 5 per cent in stack. This cuts down efficiency of stack.

TEMPERATURES AND DRAFT PRESSURES

Series	A	B	C	D
Temperatures, deg. fahr.:				
Breeching	464	390	277	249
Bottom Landing	370	324	226	194
Top Landing	346	313	.....	.....
Top	328	270	206	173
Average from Curve	357	310	221	190
Outside Air	40	38	43	24
Pressures, inches:				
Barometer	30.06	30.00	29.63	30.27
Draft, bottom	0.772	0.697	0.518	0.555
Draft, top	0.038	0.032	0.048	0.05
Draft, for 130 ft.	0.734	0.665	0.470	0.500
Calculated draft for 130 ft.	0.752	0.685	0.492	0.504

See *Power*, September 16, 1919, or address Julian C. Smallwood. Johns Hopkins University, Baltimore, Md.

Properties of Engineering Materials A3-19 Zirconium Steel. The Bureau of Standards is preparing a report showing the heat treatment, impact test and tensile strength of a large number of plates submitted to the Navy for ballistic tests. Thirty-six samples of zirconium steel were analyzed at the Bureau. It has been found that steels which contain boron may be successfully rolled if the temperature is kept below 1000 deg. cent. Bureau of Standards, Washington, D. C. Address S. W. Stratton, Director.

Properties of Engineering Materials A4-19 Manila Rope. The action of muriatic acid on manila rope as occurs when used to support swinging staging for washing down brick is such that the fumes weaken the rope seriously without any superficial trace of the action being noticeable to the eye. The only practicable remedy is to treat the rope with some acid-resisting compound. Bureau of Standards, Washington, D. C. Address S. W. Stratton, Director.

Properties of Engineering Materials A5-19 Concrete Columns and Protective Plasters. The work of the Bureau of Standards previously reported has been carried on in making fire tests of full-size columns with different forms of protection and of different aggregate. It has been found that columns made from Cow Bay gravel which contains a large proportion of granite and gneiss pebbles and columns made from pure quartz gravel give results which are not quite so good as those from columns made from Pittsburgh gravel. The columns of this latter form had protective concrete spalled so badly that the steel and load-bearing concrete were exposed to the fire and failed before the completion of the four fire tests. Columns with coarse aggregate of trap rock showed no tendency to spall. To protect columns gypsum forms have been used in the construction of the columns and these forms are allowed to stay in place as a protective cover. These have given excellent protection. When the protective covering was made of plaster of portland cement and sand, the results were good but not so good as those from trap rock and slag. Bureau of Standards, Washington, D. C. Address S. W. Stratton, Director.

B—Research in Progress

The purpose of this section of Engineering Research is to bring together those who are working on the same problem for coöperation or conference, to prevent unnecessary duplication of work and to inform the profession of the investigators who are engaged upon research problems. The addresses of these investigators are given for the purpose of correspondence.

Air B4-19 Blowers. Performance of blowers operating in parallel. No. 797. U. S. Naval Experiment Station, Annapolis, Md. Address Bureau of Steam Engineering, U. S. Navy, Washington, D. C.

Air B5-19 Orifices. Flow of air through orifices from the atmosphere into a vacuum. No. 704. U. S. Naval Experiment Station, Annapolis, Md. Address Bureau of Steam Engineering, U. S. Navy, Washington, D. C.

Apparatus and Instruments B14-19 Screw Threads. Precision Measurements of Screw Threads. Pratt and Whitney Company, Hartford, Conn.

Electricity B1-19 Electricity in Mines by L. C. Ilsley. This investigation is to cover permissibility, explosion-proof motors, portable electric mine lamps, flame safety lamps, gas detectors, permissible electric headlights, electric lamps for rescue service, electric flash lamps, single-shot blasting units, multiple-shot blasting units, storage-battery locomotives, electric trip lamps, field investigation, laws and rules governing the use of electricity in mines. Bureau of Mines, Washington, D. C. Address Van H. Manning, Director.

Electric Power B4-19 Carbon Electrodes. An investigation on the manufacture of carbon electrodes to devise method for manufacture of large carbon electrodes from western material by L. C. Duschak,

Bureau of Mines, Washington, D. C. Address Van H. Manning, Director.

Gases, General B1-19 Production of hydrogen from crude oil for use in balloons, test 1097. U. S. Naval Experiment Station, Annapolis, Md. Address Bureau of Steam Engineering, U. S. Navy, Washington, D. C.

Gases, General B2-19 Production of hydrogen from steam and coal, and by electrolysis of salt solution, test 1161. U. S. Naval Experiment Station, Annapolis, Md. Address Bureau of Steam Engineering, U. S. Navy, Washington, D. C.

Hydraulics B½-19 Flow of oil through orifices and tubes, No. 665. U. S. Naval Experiment Station, Annapolis, Md. Address Bureau of Steam Engineering, U. S. Navy, Washington, D. C.

Hydraulics B5-19 Condenser Tubes. Investigation to determine the effect of temperature, tube length and water velocity upon friction loss in water flowing through condenser tubes, No. 789. U. S. Naval Experiment Station, Annapolis, Md. Address Bureau of Steam Engineering, U. S. Navy, Washington, D. C.

Internal-Combustion Motors B7-19 High-Altitude Performance. The Bureau of Standards is testing a 300-hp. Hispano-Suiza engine at conditions on the ground and at 25,000 ft. elevation at various speeds and under different openings of throttle. Bureau of Standards, Washington, D. C. Address S. W. Stratton, Director.

Internal-Combustion Motors B8-19 Ignition. The Bureau of Standards is endeavoring to detect turbulence within a gas-engine cylinder and to determine its effect upon the velocity of flame propagation. Turbulence seems to be without effect in the vertical plane while with advanced spark the velocity of propagation increases. Bureau of Standards, Washington, D. C. Address S. W. Stratton, Director.

Internal-Combustion Motors B9-19 German Truck engines. The Bureau of Standards is examining the engines of several German motor trucks. Bureau of Standards, Washington, D. C. Address S. W. Stratton, Director.

Lubricants B½-19 Lubricating Oils. Investigations pertaining to the methods for the examination of lubricating oils in conjunction with Committee D-2, A.S.T.M., U. S. Naval Experiment Station, Annapolis, Md. Address Bureau of Steam Engineering, U. S. Navy, Washington, D. C.

Lubricants B5-19 Frictional qualities of paraffin- and asphaltic-base mineral oils and of animal oils. U. S. Naval Experiment Station, Annapolis, Md. Address Bureau of Steam Engineering, U. S. Navy, Washington, D. C.

Lubricants B6-19 A fractional distillation of lubricating oils before and after use. Continuation of the work reported in the Journal A.S.N.E., for May, 1917. U. S. Naval Experiment Station, Annapolis, Md. Address Bureau of Steam Engineering, U. S. Navy, Washington, D. C.

Lubricants B7-19 The cause of emulsifying properties of oils with water in turbine oils, test 680. U. S. Naval Experiment Station, Annapolis, Md. Address Bureau of Steam Engineering, U. S. Navy, Washington, D. C.

Lubricants B8-19 Methods of analyses of lubricating greases, test 822. U. S. Naval Experiment Station, Annapolis, Md. Address Bureau of Steam Engineering, U. S. Navy, Washington, D. C.

Machine Tools B3-19 Milling Hobs. Side Cutting of Thread-Milling Hobs. Address Pratt & Whitney Company, Hartford, Conn.

Machine Tools B½-19 Machine-Tool Investigations. To determine the power required and the action of various types of cutting tools and the effect of heat treatment of tool steel. A planer at the Bureau of Standards has been equipped with a dynamometer, and various pyrometers and potentiometers have been calibrated. This work is being carried out in connection with machine-tool manufacture. Bureau of Standards, Washington, D. C. Address S. W. Stratton, Director.

Metallurgy and Metallography B7-19 Deep Etching of Steel. The Bureau of Standards is carrying on work on deep etching of steel which so far seems to reveal a chemical heterogeneity, mechanical non-uniformity and physical discontinuities. Steels which are highly stressed internally often split open spontaneously under the action of concentrated acids. Magnetic investigation locates defects in materials which had developed transverse fissures in service in the same manner that deep etching reveals this. Bureau of Standards, Washington, D. C. Address S. W. Stratton, Director.

Metallurgy and Metallography B8-19 Crucibles. Microscopic investigations of graphite crucibles by A. C. Fieldner and Reinhardt Theissen. The aim of this investigation is to discover the merits of various graphites used in crucible making and whether or not American graphites can be substituted favorably for foreign graphites and to overcome difficulties in crucible making. Bureau of Mines, Washington, D. C. Address Van H. Manning, Director.

Metallurgy and Metallography B9-19 Electric-Furnace Work. Electric brass-furnace practice in the United States, by H. W. Gillett, Bureau of Mines, Washington, D. C. Address Van H. Manning, Director.

Metallurgy and Metallography B10-19 Ferroalloys, by H. W. Gillett. Continuation of War Materials Investigations on ferromanganese and silicomanganese, ferrouranium and ferrozirconium. Bureau of Mines, Washington, D. C. Address Van H. Manning, Director.

Metallurgy and Metallography B11-19 Studies of the effect of heat treatment on microstructure and properties of metals. Test 602, and tests of failed materials. U. S. Naval Experiment Station, Annapolis, Md. Address Bureau of Steam Engineering, U. S. Navy, Washington, D. C.

Metallurgy and Metallography B12-19 Sulphur and Phosphorus Content in Steel. The Bureau of Standards is planning a laboratory investigation and service tests involving the coöperation of steel manufacturers, users and the Bureau of Standards to determine the phosphorus and sulphur limits for specifications of various kinds of steel. Address Bureau of Standards, Washington, D. C. Address S. W. Stratton, Director.

Metallurgy and Metallography B13-19 Ferrous Metallurgy, by Francis B. Foley. An investigation in coöperation with the National Research Council to determine whether or not brittleness is induced in carbon steels by slow cooling from below the critical temperature, also to attempt to determine the cause and effect of certain defects in nickel ordnance steels. Bureau of Mines, Washington, D. C. Address Van H. Manning, Director.

Oils B2-19 Oil-Extraction Equipment. A study of present types of equipment for extracting animal and vegetable fats and oils from oleaginous material by means of volatile solvents, particularly from the standpoint of economy, ease of operation and quality of finished product. Address J. H. Shrader, U. S. Bureau of Agriculture, Washington, D. C.

Properties of Engineering Materials B½-19 Limestone tests are being made on Indiana Limestone to establish data for the grading of this stone. Panels are being erected exposed to the weather so as to find the cause of discoloration. Various mortars and various methods of waterproofing are used. Bureau of Standards, Washington, D. C. Address S. W. Stratton, Director.

Properties of Engineering Materials B5-19 Frost-Action Tests. Commercial sandstones are being tested by the Bureau of Standards to determine the disintegration under freezing. High-grade sandstones have stood 300 freezings with but few signs of disintegration, while poorer grades were completely broken down in less than 100 freezings. Granite passed through 300 freezings without showing any signs of freezing, while porous limestone began to disintegrate after 150 freezings. Bureau of Standards, Washington, D. C. Address S. W. Stratton, Director.

Textile Manufacture and Clothing B3-19 Determination of the permeability of balloon fabric by hydrogen. U. S. Naval Experiment Station, Annapolis, Md. Address Bureau of Steam Engineering, Washington, D. C.

Wastes B1-19 Wastes, Vegetable, Utilization of. Mechanical and Industrial problems connected with commercializing waste products either discarded or marketed disadvantageously at present. Address Dr. J. H. Shrader, U. S. Bureau of Agriculture, Washington, D. C.

F—BIBLIOGRAPHIES

The purpose of this section of Engineering Research is to inform the profession and especially the members of the A.S.M.E. of bibliographies which have been prepared. These bibliographies have been prepared at the request of members, and where the bibliography is not extensive this is done at the expense of the Society. For bibliographies of a general nature the Society is prepared to make extensive bibliographies at the expense of the Society on the approval of the Research Committee. After these bibliographies are prepared they are loaned to the person requesting them for a period of one month. Additional copies are prepared which are available for periods of two weeks to members of the A.S.M.E. or to others recommended by members of the A.S.M.E. These bibliographies are on file in the offices of the Society and are to be loaned on request. The bibliographies are prepared by the staff of the Library of the United Engineering Society, which is probably the largest Engineering Library in this country.

Air F½-19 Use of Compressed Air in Petroleum Oil Wells. A bibliography of 2½ pages. Search 2682. Address A.S.M.E., 29 West 39th St., New York.

Fuels, Gas, Tar and Coke F½-19 Coals Used in Producers. A bibliography of 1 page. Search 2681. Address A.S.M.E., 29 West 39th St., New York.

Fuels, Gas, Tar and Coke F5-19 Extraction of Gasoline from Natural Gas. A bibliography of 3¼ pages. Search 2717. Address A.S.M.E., 29 West 39th St., New York.

Oils F1-19 Extraction and Refining of Cocoanut or Copra Oil. A bibliography of 12½ pages. Search 2523. Address A.S.M.E., 29 West 39th St., New York.

Railroad Tracks and Signals F1-19 Mechanically Operated Railway Signals. A bibliography of 3 pages. Search 2704. Address A.S.M.E., 29 West 39th St., New York.

WORK OF THE BOILER CODE COMMITTEE

THE Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Any one desiring information as to the application of the Code is requested to communicate with the Secretary of the Committee, Mr. C. W. Obert, 29 West 39th St., New York City.

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are sent by the Secretary of the Committee to all of the members of the Committee. The interpretation, in the form of a reply, is then prepared by the Committee and passed upon at a regular meeting of the Committee. This interpretation is later submitted to the Council of the Society for approval, after which it is issued to the inquirer and simultaneously published in MECHANICAL ENGINEERING, in order that any one interested may readily secure the latest information concerning the interpretation.

Below are given the interpretations of the Committee in Cases Nos. 243, 244, 247-256, inclusive, as formulated at the meeting of September 26, 1919, and approved by the Council. In this report, as previously, the names of inquirers have been omitted.

CASE No. 243

Inquiry: Is the design of a vertical single-flue boiler, as shown in Fig. 2, which is formed of a seamless steel tube for the vertical flue, expanded into openings in the crown sheet and top head of the boiler, acceptable under the requirements of the A.S.M.E. Boiler Code?

Reply: A boiler of the vertical single-flue type, constructed with dished heads for crown sheet and top head, in order to come under the requirements of the Boiler Code, must conform to the requirements of Par. 195, dealing with a dished head having a flanged opening supported by an attached flue (see page 50, last sentence of Par. 195, Edition of 1918). To meet this requirement, the flue which connects the top head and crown sheet of the boiler should be attached by a riveted flanged connection at each head.

CASE No. 244

Inquiry: Will it be permissible to use lap-welded steel pipe for the grate headers used on down-draft furnaces of the Hawley type if the material conforms to any one of the specifications in the Boiler Code?

Reply: Under the requirements of Par. 9, pressure parts for grate headers on down-draft furnaces and of other similar parts to be used for boiler construction, may be constructed from material which in its initial form of plate or skelp, conforms to one or the other of the specifications given in the Boiler Code for wrought steel, or they may be constructed of cast steel of Class B grade. If the header referred to in this case is built of lap-welded steel, any steel that will conform with the requirements of the specifications in the Code may be used.

CASE No. 247

Inquiry: In fitting twin safety valves to a boiler, is it permissible to mount valves of different sizes, or shall the requirements of the Boiler Code be construed to require valves of equal sizes?

Reply: There is no requirement in the Boiler Code which covers this case. The Committee, however, recommends that the valves be made of equal sizes, if possible, and that in any event the smaller of the two valves shall have a relieving capacity of at least 50 per cent of that of the larger valve.

CASE No. 248

Inquiry: Is it necessary under the material requirements of the Boiler Code that a connecting pipe external to the boiler setting between the boiler and superheater be made of open-hearth quality lap-welded pipe, or may bessemer steel pipe be used?

Reply: It is the opinion of the Committee that pipe connections external to the boiler setting do not come under the requirements of the Boiler Code, but it is recommended by the Committee that since this is a part of the boiler proper in the sense that it cannot be closed off by intervening valves, pipe connections of open-hearth-steel material should be used.

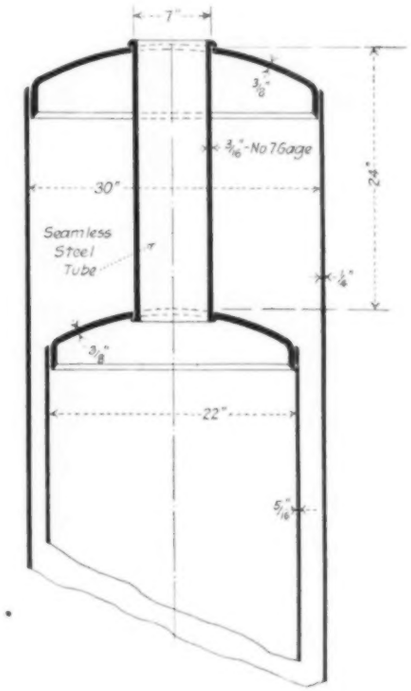

FIG. 2 A DESIGN OF VERTICAL SINGLE-FLUE BOILER

CASE No. 249

Inquiry: Is Par. 427*e* of the Boiler Code applicable to water glasses of the chain-pull, quick-closing type, in which there is a limit of movement of about one-third revolution of the valve stem? This requirement appears to be a practically impossible construction for an automatic gage of the quick-closing type.

Reply: It is the opinion of the Committee that for chain-pull, quick-closing-type water glasses, the requirements in Par. 427*e* can be met by the application of a pulley over which the chain-pull may be operated to turn the valve stem the necessary amount.

CASE No. 250

Inquiry: Is it permissible for qualified boiler inspectors to transfer stampings to the remnants from flange or firebox boiler plate which bear no identifying mark, yet are none the less available for use?

Reply: It is the opinion of the Committee that under the requirements of the material specifications of the Boiler Code, it is not permissible for boiler-plate stampings to be transferred by any one except an authorized mill agent or representative. Attention is called to the fact that under Par. 36 of the Code, markings are required to appear in the completed boiler only on shells, heads and butt straps.

CASE No. 251

Inquiry: Will the requirement in Par. 291 of the Boiler Code, which specifies that a gage glass shall be set not less than 2 in. above the lowest permissible water level, not be inclined to cause lifting of water through the steam outlet or by the operation of

the safety valve, in a small return tubular boiler having only a 12-in. segment above tubes and a fusible plug set 2 in. above tubes which would thus reduce the steam space from 12 to 8 in.?

Reply: It is the opinion of the Committee that a suitable internal collecting pipe or splash plate may be employed to advantage in such a case.

CASE No. 252

(In the hands of the Committee)

CASE No. 253

(In the hands of the Committee)

CASE No. 254

Inquiry: Is it permissible to burn out tube holes with the oxy-acetylene torch, provided the amount of metal removed does not exceed that required by Par. 248 of the Boiler Code, and that they be finished as provided therein? Also is it permissible to burn off surplus metal from the edges of plate by means of the oxy-acetylene torch provided the full amount of metal is removed thereafter as required by Par. 257 of the Boiler Code? In other words, the purport of the above inquiries is in brief — may the burning process be substituted for the punching and shearing processes?

Reply: It is the opinion of the Committee that this method is allowable where punching or shearing is specified, and where the edges are afterward machined by drilling, reaming, chipping or planing to remove a specified amount of material as required by Pars. 248 and 257 of the Boiler Code.

CASE No. 255

Inquiry: Does the requirement in the reply for Case No. 218 that headers and manifolds of superheaters must be constructed from material which in its initial form of plate or skelp conforms to one or the other of the specifications in the Boiler Code for wrought steel, or they may be constructed of cast steel of Class B grade, require that if the Specifications for Lap-welded and Seamless Boiler Tubes are to be met, that the flattening test be met and the material as specified for the tubes be also met?

Reply: It was intended in the reply to Case No. 218 to specify the quality of the material in its initial form of plate or skelp and not to require tests of the completed tube, so that the flattening tests referred to in the Specifications need not be considered in this connection.

CASE No. 256

(In the hands of the Committee)

ARMY MOTOR-TRANSPORT VEHICLES

(*Continued from page* 863)

truck carrying 1200 gal. of water was fitted with a heating device taken from a steam car, enabling the water to be brought to a good temperature. A centrifugal pump at the front end of the tank, geared to the engine of the truck, pumped this hot water under pressure through hose pipe to a system of gas piping with spray nozzles allowing twenty-four soldiers to have shower baths simultaneously. Attached to this truck was a trailer or sometimes another truck carrying the cleaned clothing. Its mobility allowed it to be kept in close contact with the front line, where full service could be given. Incidentally, this was similarly used for delousing purposes and ordinary shower baths.

SPECIAL FEATURES FOR MILITARY WORK

Military operation demands special equipment. Trucks operated in convoy over long periods of time tend to make the drivers "dopy"; the short space separating the trucks is not always sufficient to prevent one truck running into another either backward or forward, therefore ample rear and fore bumpers or guards must be provided. Proper towing hooks must also be provided front and rear to enable a disabled truck to continue its journey, for supplies must not be left behind. The standard artillery type of pintle hook is now universal at the rear of American military trucks and at the front two hanging towing hooks are provided, one on each side of the frame.

In running in convoy a tremendous amount of dust is raised and often drivers in the middle and rear are almost unable to see through this fog. This dust finds its way through the air intake into the carburetor, into the engine and causes rapid wear of the piston, cylinders and other parts. This is a problem peculiar not only to military operation, but also to agricultural-tractor operations. The remedy is found in the provision of an air-cleaning device to filter out the dust and grit, allowing only clean air to enter the engine.

Extra wide drivers' seats must also be provided. Provision must be made for two soldiers to sit alongside the driver, and soldiers with their heavy overcoats and various accouterment are necessarily bulky. A reserve supply of gasoline must likewise be provided for, and this was done in some of the military trucks by the provision of receptacles like milk cans. It is desirable to have special lamp equipment, on which there should be considerable research done in order to obtain sufficient light to operate, but insufficient for the enemy to notice. At the advanced front even a lit cigarette was not tolerated and driving was done either looking at the stars between the trees or by sound and, in some cases, by instinct. The motor-transport driver's job, contrary to general opinion, was among the most hazardous at the front and certainly was one of the hardest, and honor should be given to these men who kept motor transportation operating faithfully through periods of extreme stress in complete darkness, men who were as equal to their task as the machines beneath them.

CONCLUSIONS

At various points throughout this paper the question of the Army designing its own vehicles and the question of standardization have been brought out. In concluding the writer feels that it is insufficient merely to state the classification of vehicles used without drawing attention to the fact that they do not always remain new, but have to be repaired by Army help. In other words, this means using the help at one's disposal without the ability to obtain any other. Furthermore, the vehicles in order to be of economic use must be maintained and the maintenance problem must be simplified down to its very elements, and in this it is obvious that with the fewer the types of trucks the fewer will be the number of parts necessarily carried for replacement and the less the need for skilled mechanics. There should be a standardization of one type of vehicle in each classification. Perhaps the Army will decide to adopt some commercial type of vehicle as its standard; perhaps they may decide to develop their own. They should not be subject, however, to political agitation which would seek to provide them with vehicles unsuited for their direct needs. When this standard has been adopted it should be reasonably adhered to for a period of approximately five years before any serious change is contemplated (unless, of course, there is some tremendously radical alteration in motor-vehicle design).

Standardization of equipment, limitation of sizes of tires, of bodies, of lamps and tools and of all the hundred-and-one things that go to make up the various automotive equipment will be found not only desirable but highly essential. A long paper could be written on this subject alone, but it is felt sufficient to here only mention this part of the Army's problem and also state that by carrying this out the Army may be reasonably sure of having its vehicles give them a useful life of, say, ten years, if not more, without any scrappage or undue delays or economic waste due to failure to function.

A French concern has developed a traveling crane of reinforced concrete. The crane, as described in *Le Génie Civil*, has a capacity of 6600 lb. and a span of 32.8 ft. The rolling gear is removable and so attached that it can be adjusted to take care of any warping of the crane. The concrete used is made of 2.3 bbl. of cement to 1.18 cu. yd. of gravel and 0.52 cu. yd. of sand, a mixture which develops a crushing strength of about 780 lb. per sq. in. and a bond strength with the reinforcing of about 80 lb. per sq. in. To obtain a proper factor of safety, the maximum fiber stress in the concrete of compression members is limited to 498 lb. per sq. in even under the most favorable conditions.

ENGINEERING SURVEY

A Review of Progress and Attainment in Mechanical Engineering and Related Fields, as Gathered from Current Technical Periodicals and Other Sources

SUBJECTS OF THIS MONTH'S ABSTRACTS

ERRORS OF MEASURING INSTRUMENTS
THEORY OF DIMENSIONS IN A DIFFERENTIAL FORM
RELATIONS CONNECTING DERIVATIVES OF PHYSICAL QUANTITIES
SEEWER GOVERNOR FOR PELTON WATER TURBINES
IRON-CARBON-CHROMIUM ALLOYS
VICKERS DIESEL ENGINE
DIESEL ENGINES IN BRITISH SUBMARINES
CROSSLEY HEAVY-OIL ENGINE
COLD-STARTING HEAVY-OIL ENGINE
GOVERNOR GEAR OF HEAVY-OIL ENGINE
TRACTOR ENGINES AND FUEL LIMITATIONS
SPARK PLUGS IN TRACTOR ENGINES
SANDERS PRESSURE GAS TURBINE
COMBUSTION OF HEAVY FUELS IN MOTOR-CAR ENGINES
INGERSOLL DIFFERENTIAL TYPE CONTINUOUS MILLING MACHINE
ATMOSPHERIC POLLUTION
SKIMMERS IN BOILERS
CONVERTING MACHINES TO INDIVIDUAL DRIVES
CLOTHEL REFRIGERATING MACHINE, TESTS OF
NOTCHED-BAR TESTS

BUREAU OF STANDARDS

A RELATION CONNECTING THE DERIVATIVES OF PHYSICAL QUANTITIES, Mayo D. Hersey, Mem.Am.Soc.M.E. In this paper the author shows how the theory of dimensions may be used in a differential form, a procedure which appears particularly fruitful in investigating the effects of given sources of error on the performance of measuring instruments. Several examples showing the necessity for the application of this method are given and illustrated by experimental data. The application of the theory established is discussed in connection with the following cases:

(1) Variation of journal friction with size of bearing. Equations are given which enable one to predict the bearing losses of any slightly larger or smaller machine in the same geometrically similar series.

(2) The effect of gravity on a rolling-ball viscosimeter in terms of the effect produced by changing the size of the instruments.

(3) The effect of high pressure on the accuracy of a rolling-ball viscosimeter. In this case means are derived to predict the change in roll time due to any small change in liquid density such as would occur by using the tube under pressure by reference to an observation on the effect of changing the ball density. (*Scientific Papers of the Bureau of Standards*, No. 331, issued September 25, 1919, pp. 21-29, *tA*. Copies may be had by addressing the Bureau of Standards.)

EQUILIBRIUM CONDITIONS IN THE SYSTEM CARBON, IRON OXIDE, AND HYDROGEN, IN RELATION TO THE LEDEBUR METHOD OF DETERMINING OXYGEN IN STEEL, J. R. Cain and Leon Adler. It is shown that mixtures of iron oxide and acheson graphite are not, and mixtures of iron oxide with "cemented" iron or white iron (annealed or unannealed) are, reduced at 900 deg. cent. by the carbon in them when hydrogen is passed over them at rates of two liters per hour or faster. Because of these facts, it is probably impossible to determine by the Ledebur method more than 75 per cent of the oxygen present in steels as ferrous oxide. The effect of rate of passage of hydrogen on the Ledebur oxygen content of certain steels is shown. (*Abstract of Scientific Paper* No. 350, *U. S. Bureau of Standards, e*)

AN APPARATUS FOR MEASURING THE RELATIVE WEAR OF SOLE LEATHERS AND THE RESULTS OBTAINED WITH LEATHER FROM DIFFERENT PARTS OF A HIDE, R. W. Hart and R. C. Bowker. A short paper dealing with the development of a simple machine for testing the wear resistance of sole leathers and giving the results of extensive research work on the relative resistance to wear in different parts of a bend. The machine, which is described at various stages of its development up to the present time, was designed to subject leather to an abrasive action similar to that which it undergoes on a shoe sole, and to accelerate the wear so that a test could be completed in 24 hr.

The results of three extensive tests on the resistance to wear in different parts of a bend are given with detailed description of the manner in which these tests were made,— one test showing the results of comparative wearing tests both on the machine and in actual service included in this paper. The results of all investigations show that the laboratory testing machine gives a proper indication of the wearing resistance of leathers. (*Abstract of Technologic Paper* No. 147, *U. S. Bureau of Standards, e*)

HYDRAULIC ENGINEERING

Water-Turbine Governing by Dispersion

SEEWER GOVERNOR FOR HIGH-HEAD HYDRAULIC TURBINES OF THE PELTON TYPE, Dr. A. Strickler. Description of a turbine governor designed by a Swiss engineer, M. Seewer. In his system the primary method of governing, that is, the deviation of the water jet, is replaced by a simple dispersion which he secures by means of mobile guide elements located in the interior of the injection

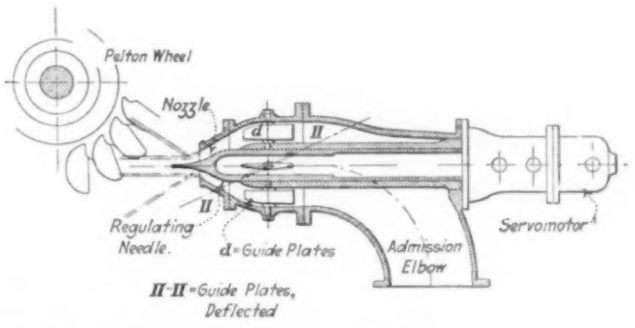

FIG. 1 SEEWER GOVERNOR FOR PELTON WATER TURBINES

nozzle. This mechanism admits of eliminating practically entirely the stresses in the primary system and reduces the path of flow to a very considerable extent, this latter being entirely independent of the diameter of the jet and power output of the turbine. Because of this the system is capable of functioning practically instantaneously and permits the use of the same governor for all sizes of turbines, the only change being in the servomotor operating the needle. It has been extensively tested at the Laboratory of the Federal Polytechnic School at Zurich.

The fundamental principle if the Seewer system of governing is expressed by the author as follows:

"The device is one in which the governing of a high-speed hydraulic turbine is effected by a change in the shape of the jet, this latter being done by guide members located in the interior of the jet nozzle and so arranged that the jet may be either practically perfectly cylindrical or may be totally or partly dispersed in accordance with the position of the guide elements."

Fig. 1 shows diagrammatically the arrangement of the device. The guide elements which are flat plates of proper shape and in proper number are located around the jet needle. They can swing about a radial axis. When these guide plates are parallel to the axis of the jet tube, the jet is perfectly cylindrical as in Fig. 2. It is a well-known fact that when the water jet is even slightly

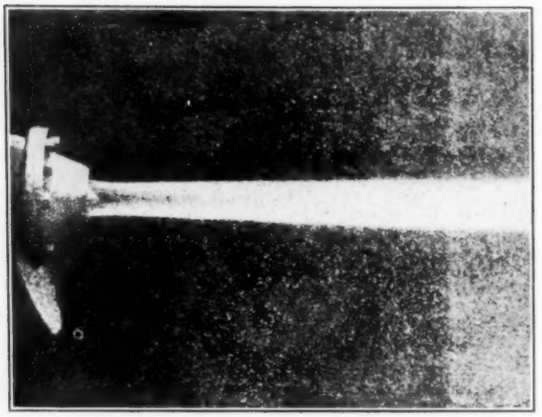

FIG. 2 FULL JET OF A PELTON TURBINE WITH SEEWER GOVERNOR AND GUIDE PLATES PARALLEL TO EACH OTHER

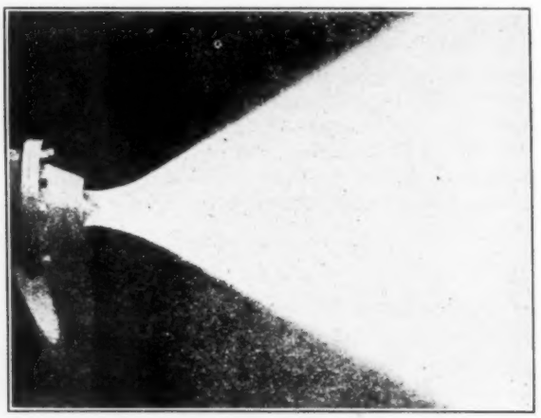

FIG. 3 DISPERSED JET OF PELTON TURBINE WITH SEEWER GOVERNOR AND GUIDE PLATES AT AN ANGLE OF 20 DEG.

dispersed this produces a material reduction in the hydraulic efficiency of the turbine, but a change in the position of the guide plates, such as shown in Fig. 1, by the line II-II, causes a complete dispersion of the jet as it comes out of the nozzle, because of which none of the water goes to the wheel in a manner to produce a useful power output.

It is easy to understand it by studying the relative path of the liquid fibers. Fig. 3 shows the dispersion of the jet caused by a displacement of the guide plates through an angle of about 20 deg.

Since the quantity of water coming out from the nozzle is practically the same with the deflected jet as with the solid jet, there is no material increase in pressure in the feed conduit, and the latter cannot suffer any harm because of a sudden deflection of the jet. *(Bulletin Technique de la Suisse Romande,* vol. 45, no. 17, Aug. 23, 1919, pp. 169-171, 3 figs. *de)*

ENGINEERING MATERIALS

ON THE STRUCTURE OF IRON-CARBON-CHROMIUM ALLOYS, Takejiro Murakami. This investigation forms the subject of the 24th Report of the Alloys Research Institute.

In the present case various iron-carbon-chromium and iron-chromium alloys have been investigated by magnetometric and thermal methods. The following are the conclusions arrived at by the author:

1 By utilizing magnetic analysis and microscopic observation the iron-carbon-chromium alloys containing less than 6 per cent of carbon have been systematically investigated, and a structural and constitutional diagram of their states has been obtained. The change of structure during heating and cooling up to 1200 deg. has also been discussed.

2 By microscopic observation a probable diagram for binary alloys of chromium and carbon containing less than 5 per cent of carbon has been determined, and this has confirmed the existence of a compound Cr_4C having a hexagonal crystal form, as put forward by Moissan, and also the formation of a eutectic consisting of the carbide and chromium dissolving the carbide.

3 Iron and chromium form a continuous series of solid solutions, whose critical point for the A_2 transformation decreases as the chromium content increases.

4 In the iron-carbon-chromium alloys there exist three ternary compounds, α, β and γ double carbides, having the probable formula $(Fe_3C)_{18}$. Cr_4C, $(Fe_3C)_9$. Cr_4C and Fe_3C. Cr_4C, respectively. The former two crystallize in a scaly form, and the latter in a hexagonal prismatic form. The α carbide is a magnetic compound, whose critical point is 150 deg., while the other two are non-magnetic.

5 Under microscopic observation, these carbides can easily be differentiated from each other by means of a new reagent, an alkaline solution of potassium ferricyanide. By this reagent, γ carbide is intensely colored brown to blue in cold and β carbide equally colored by the same reagent at boiling temperature, while these carbides are not acted on by picrate boiling. α carbide is colored brown both by a boiling ferricyanide solution and also by picrate.

6 The lowering of the transformation point is caused by dissolved chromium. Above Ac_1 point the carbide Cr_4C dissolves in austenite and by heating to a suitably high temperature it dissociates according to the following scheme:

$$2\ Cr_4C = Cr_3C_2 + 5\ Cr$$

The higher the temperature, the more the above change proceeds from left to right. During cooling, the recombination of Cr_3C_2 and chromium to the carbide Cr_4C takes place only slowly, and therefore, in alloys containing the carbide Cr_4C, the carbide change is lowered by the normal cooling from a high temperature by the retarding action of the dissolved chromium.

7 The cooling rate has generally a marked effect on the position of the transformation points. If the rate be very large, the transformation is very conspicuously lowered, and in some cases is completely suppressed. On the contrary, if the rate of cooling through a range of 700 deg. be sufficiently slow, the carbide change takes place within the range.

8 The cooling magnetization-temperature curves of a specimen and its microstructure have a close connection with each other. A specimen having the normal transformation point shows the troostitic or pearlitic structure, the one having the lowered transformation the martensitic, and the other having the completely suppressed transformation the austenitic structure.

9 The self-hardening of a chromium steel is related to the lowering or complete suppression of the Ar_1 transformation; the hardness is caused by the solid solution of the carbide Cr_3C_2 in iron dissolving chromium.

10 The Ac_1 and Ar_1 points in chromium steels are raised as the chromium content increases, and the former becomes higher than the Ac_2 point from high-chromium steels. *(Science Reports of the Tohoku Imperial University,* First Series, vol. 7, no. 3, December 1918, pp. 219-276 and 20 plates, *et A)*

INTERNAL-COMBUSTION ENGINEERING

Diesel Engines Used in British Submarines

VICKERS DIESEL ENGINE. Some data on the design of the Vickers Diesel engine, which is of particular interest since practically the whole of the British submarine fleet is driven by these engines.

The engines described are mainly those of the Trefoil type, a war-time production built in the greatest hurry to meet a national emergency.

The eight cylinders of each set—17 in. bore by 27 in. stroke—are based upon the submarine design, and are of the simplest possible form, consisting of a plain liner, of which the head is held in a cast-steel entablature which is common to a pair of cylinders, and which forms the upper part of the water jacket (compare Fig. 4). The lower part consists of a light galvanized wrought-iron cylinder held by the entablature and jointed to the lower end of the liner by rubber rings. This design is not suitable, however, to purely commercial work. The cover is a simple steel casting carrying the inlet and exhaust valve and the fuel nozzle and relief valve, the cooling water passing direct from the cylinder jacket to the interior of the cover without the more usual little pipe connection.

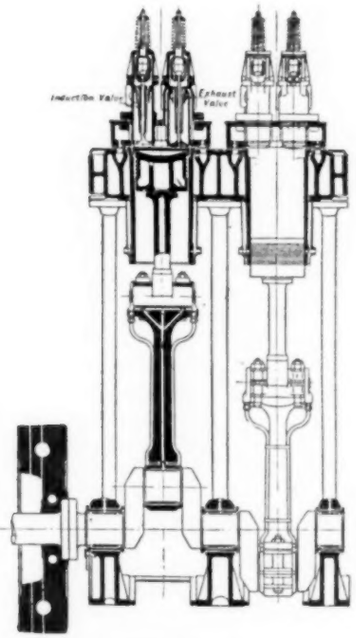

FIG. 4 CYLINDER CONSTRUCTION OF THE TREFOIL TYPE VICKERS DIESEL ENGINE

The submarine engine framing is shown in Fig. 5, which consists simply of an A-shaped piece of boiler plate placed athwartships between the cylinders, something less than an inch in thickness, lightened out and with a forged-steel flange top and bottom riveted on to take the cylinder and bedplate bolts, with light iron angles riveted along the sides to act as stiffeners and to take the splash plates. Increased lateral stiffness is obtained by horizontal fore and aft plates between each pair of columns, which improves the bottom of the water jacket. This kind of framing was suitable for the submarine engine with its trunk piece, but the engines of the Trefoil have ordinary crosshead and guide. Because of this, in the Trefoil engine each cylinder has a cast-iron box column at the back carrying the guide, and well splayed fore and aft at the foot, in addition to which there is a turned steel column in front at each main bearing.

The crosshead arrangement allows of a very short piston which is not water-cooled. As a cylinder only gives something less than 100 b.hp., the total power of each set of eight cylinders is 750 b.hp. at 1500 r.p.m.

The top end of the connecting rod is novel, as the whole of what is ordinarily the fork is used as a bearing surface for the gudgeon pin.

Solid injection is used and the four fuel pumps deliver into a common pipe for all the cylinders. From that pipe the spray valves are fed, the regulation of the fuel injected being effected by the adjusting the duration of opening of the spray valves, the

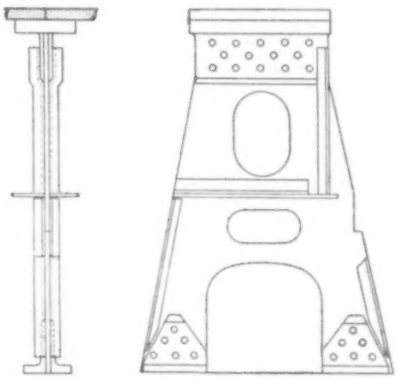

FIG. 5 SUBMARINE ENGINE FRAMING VICKERS DIESEL ENGINE

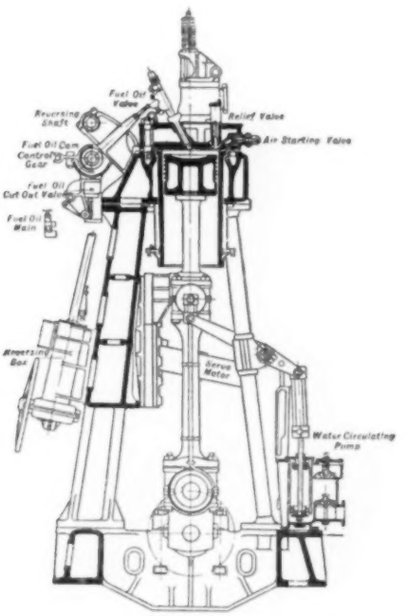

FIG. 6 CYLINDER CONSTRUCTION AND REVERSING ARRANGEMENT OF TREFOIL TYPE VICKERS DIESEL ENGINE

fuel pressure in addition being reduced at low power from the 3750 lb. or so, used at full speed.

For reversing, a special reversing shaft is provided above the camshaft, which latter runs along the top of the cylinders and is driven by a vertical shaft through bevel gears. This reversing shaft carries two rockers for each valve on eccentric fulcra, so disposed (Fig. 6) with regard to each other that when one is engaged with its cam the other is clear, the two corresponding cams on the camshaft being fixed on that shaft for ahead and astern going, respectively. Thus, a half turn of the reversing shaft puts the inlet and exhaust valves right for the intended direction of rotation, but the fuel cam block with its ahead and astern cams has to slide along the shaft by means of a separate maneuvering shaft, and this can be done without the necessity of raising the rockers clear of the cams by reason of a slope on the side of the nose of the cams. Control of the period of fuel injection is ob-

tained in a very simple way by the eccentric mounting of the fulcrum of the fuel valve rocker.

When the cams are set in the proper position the master air valve is opened and air delivered to four little cam-operated valves, which deliver the air through separate pipes to non-return valves in each cylinder head, the valves and cams being on a vertical shaft and situated near the starting handles. (*The Engineer*, vol. 128, no. 3322, August 29, 1919, pp. 198-200, 4 figs., *d*. Compare also the reprint of the article in the *Journal of the American Society of Naval Engineers*, vol. 31, no. 3, August 1919, pp. 661-671, 5 figs.)

Novel Type of Heavy-Oil Engine and Its Governor

THE CROSSLEY COLD-STARTING HEAVY-OIL ENGINE. Description of an engine of British design in which the use of the lamp for starting has been done away with.

The engine belongs to the type of heavy-oil engines, but cannot be correctly described as being either a Diesel or semi-Diesel. In

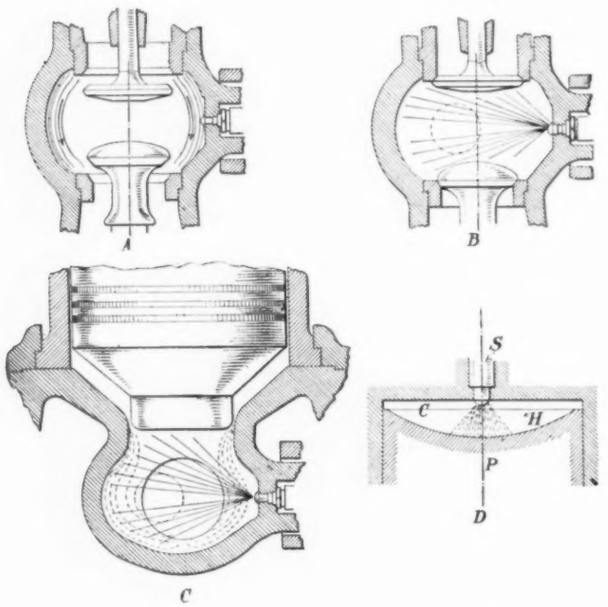

FIG. 7 COMBUSTION CHAMBER IN CROSSLEY HEAVY-OIL ENGINE

fact, it would appear as if the engine, in some respects, was in a class by itself. The essential characteristic feature of the engine is the shape of its combustion chamber, which, as shown in Fig. 7, *C*, is spheroidal.

The theory underlying this construction is that a spherical chamber will give the least wall surface exposed to the water jacket, and will permit of a central core of air heated by compression and cooled as little as possible by contact with the walls. This core is relied on to fire the charge.

The change from spherical to spheroidal is rendered necessary by the cooling effect of the incoming charge of fuel which tends to transfer the central core towards the left, as indicated by the dotted circle in *C*. If the chamber were spherical this would bring it into contact with the water-cooled walls, but by making the chamber spheroidal a good clearance is provided between the hot core and the jacket. It is contended that this hot core is essential if a low compression pressure and low injection pressure are to be used, as it allows the fuel to be kept in contact with the heat for a longer period than would be the case in a Diesel engine. It is this feature that permits the Crossley engine to use a compression pressure as low as 300 lb. per sq. in. and a fuel injection pressure of only 1000 lb. with solid injection.

In order to further insure the thorough mixture of the air and fuel turbulence is produced by the shape of the top of the piston, which, at the top of the stroke, projects into the combustion chamber and forms a plug past which the air is driven at high speed by the rising piston round the walls of the chamber, but without disturbing the hot core, as shown by the dotted lines along the walls in Fig. 7, C.

Fig. 8 gives some test curves of the Crossley engine on various fuels, such as paraffin (kerosene), residual petroleum and tar oil. These figures were obtained from tests made by Professor Burstall on a single-cylinder engine 18½ in. bore by 28 in. stroke. The figure of 32.2 per cent thermal efficiency is unusual for such a simple single-cylinder engine.

The article also describes the governor gear of the engine. The governing of the engine is effected by the opening of a bypass or control valve *K*, Fig. 9, in the oil fuel pipe between the oil pump *J* and the oil sprayer at variable points in the pump delivery stroke, according to the load at which the engine is working. For instance, at medium load the control valve will be opened at about half-pump stroke, the remainder of the oil in the pump, instead of passing into the combustion chamber, being by-passed through the control valve *K* and pipe *T* to the funnel shown at *U* in Fig. 10, whence it flows back to the oil heater *V*. The means of operation of the control valve are shown in Fig. 9. The floating lever *F*, opposite the end of the control-valve spindle, is pivoted at its bottom end to an arm on the pump-lever spindle. The upper end of the lever *F* rests against a quadrant *H*, the position of which is controlled by the governor *G*. The quadrant has a cam-shaped periphery, and as the governor rises and falls the upper end of the floating lever is pushed to and fro in a direction toward or from the end of the control-valve spindle. When the pump plunger moves forward the upper end of the floating lever becomes the fulcrum of the lever, and the position of this fulcrum being shifted by the governor the control valve is opened at a varying time, according to the load and speed of the engine.

When using viscous fuels which do not readily atomize at normal atmospheric temperatures a change-over fuel device is provided

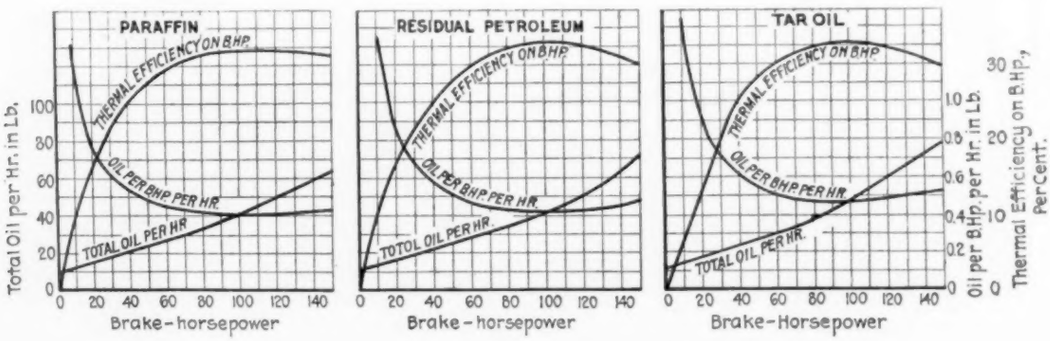

FIG. 8 TEST CURVES OF THE CROSSLEY ENGINE ON VARIOUS FUELS

to enable a less viscous fuel to be used for a few seconds or minutes when starting the engine. This change-over gear consists of an eccentric pin in the fuel pump placed between two suction valves and operated by the weighted hand lever shown at *Y* in Fig. 9. When this lever is in the position shown the lower valve is kept on its seat and a supply of less viscous fuel, such as paraffin, gas oil, or crude oil, poured into the cup *X*. When the engine is

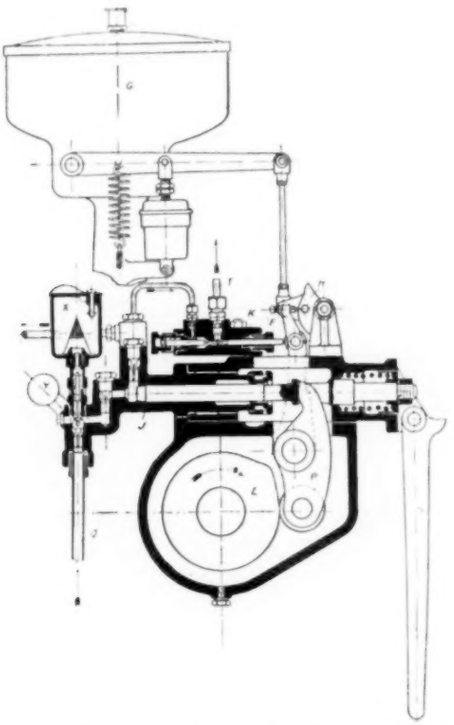

FIG. 9 GOVERNOR GEAR OF THE CROSSLEY OIL ENGINE

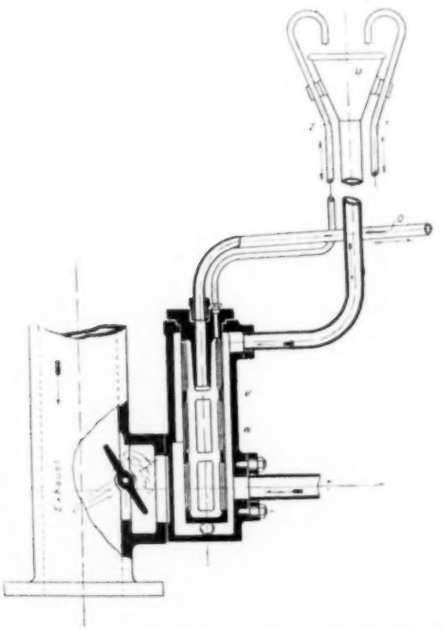

FIG. 10 OIL HEATER OF THE CROSSLEY HEAVY-OIL ENGINE

started the pump will draw its supply from the cup. After a few revolutions the weighted handle *Y* is moved over, the upper valve being then closed and the lower valve opened, enabling the pump to suck its charges from the pipe *Q*, which is connected directly to the oil heater *V* shown in Fig. 10, through which the viscous oil is passed on its way from the oil tank to the pump to reduce its viscosity. The oil heater is attached to the exhaust pipe of the engine and the temperature of the heater can be adjusted by means of the large wing valve shown, which varies the amount of the exhaust gases which are allowed to pass through the connecting passages. A larger strainer *W* is fitted in the oil heater. In case any vapor is formed or frothing of the oil takes place in the oil heater, a vent pipe *Z* is fitted at the top of the heater and taken up to the top of the funnel, when any emission can readily be observed. A hand lever *S* is provided for filling the pump with oil before starting the engine.

To stop the engine a small screw-down valve is opened in the oil delivery pipe between the oil pump and the oil sprayer. The effect is to deliver all the oil to the funnel, and the combustion chamber being no longer supplied with fuel the engine immediately slows down and stops.

An interesting point is worthy of note in connection with the method of governing as described above, and this is that as the fuel, while being delivered, is actually producing power at that instant the cutting off of the supply of fuel at different points of the pump stroke, according to the position of the governor, means that the governing effect takes place at the identical moment that the fuel is being injected and burned, and therefore has an instantaneous effect between the fuel and the power. It is certainly a remarkable engine; it has the economy of many Diesel engines, and yet it has solid injection at low pressure and no air compressor; it has only 300 lb. compression pressure with the accompanying advantages of cheaper and lighter construction, and yet it can use the heavy oils, and it starts from all cold without the need for a lamp, and it should require only comparatively unskilled attention. (*The Engineer*, vol. 128, no. 3324, September 12, 1919, pp. 252-254, 5 figs., *d*)

TRACTOR ENGINES AND FUEL LIMITATIONS, H. L. Horning, Mem. Am.Soc.M.E. Among other things the writer discusses the question of spark plugs, and gives the following specifications as to the location of the spark plugs and their design:

1 The plug should be located as near as possible to the center of gravity of the mixture in the combustion chamber when the mixture is about to fire

2 It should be so located as to be out of the exhaust-gas stream

3 It should be located so as to get the blast of this incoming rich mixture, or in such a place as will insure that the mixing surrounding this electrode will be highly explosive and not deadened by a residual charge

4 The cooling-water stream which has picked up a large volume of heat from the exhaust-valve environment usually insures temperature enough to keep a good clean plug and a cooling effect that will keep preignition out of the probabilities

5 No cylinder head should be designed which will demand a long spark plug to reach the mixture

6 A vertical spark plug is the only type which runs a long time without cleaning. The necessity of putting spark plugs at an angle if not horizontal in the head of a valve-in-head engine is one of the inherent defects of that type of engine. This is due to a cleaner oil drainage from the plug vertically placed

7 The plug should not be placed so as to get the direct sweep of gases passing by the piston and rings on the suction stroke.

The above considerations are particularly for the guidance of the engine designer. Beyond this he should keep in mind that the engine must work irrespective of where the farmer buys his plugs or their design.

Should the user desire advice as to the type of plug, it is only necessary to observe the following points:

1 The insulator should be of the best grade of porcelain or stone now available

2 The center electrode should be at least 3/32 in. in diameter, well smoothed off, rounded, and the distance of its top

from the outside air a minimum. Cooling ribs are very desirable. No sharp corners or points should be presented to the combustion chamber

3 It is not easy to give general specifications for a good mica plug, although there are many. As a class they are to be avoided.

Aside from temperature problems the greatest difficulties with spark plugs arise out of the limitations of the fuel, resulting in a deposit of carbon. Excessive lubrication in the combustion chamber can result from heavy fuel and further favors the short-circuiting of the plug with oil and carbon. (*Journal of the Society of Automotive Engineers*, vol. 5, no. 3, September, 1919, pp. 265-271, 4 figs., *gp*)

Skew-Gear Type of Pressure Gas Turbine

SANDERS PRESSURE TURBINE. Essentially the turbine consists of two elements of a skew gear. At the points of mesh a tooth of one element in passing down the groove between two teeth of the

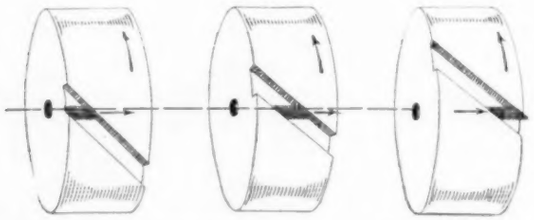

FIG. 11 DIAGRAM ILLUSTRATING THE LATERNAL MOVEMENT OF PISTON TOOTH IN A DIAGONAL CYLINDER SLOT OF THE SANDERS GAS TURBINE

other element is utilized as a constant-velocity piston traveling down the equivalent of a cylinder.

Shrouding around these two elements allows a series of ports to be placed in positions which insure at various points of revolution,

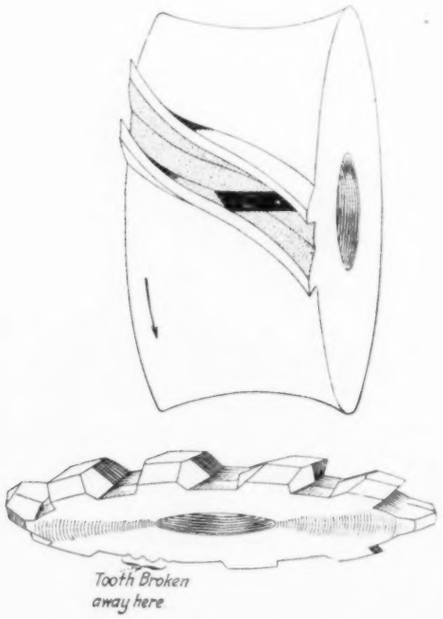

FIG. 12 DIAGRAM SHOWING RELATION BETWEEN SKEW-GEAR CYLINDER WHEEL AND PISTON WHEEL

first, the admission of an explosive mixture under pressure; second, the uncovering of a small chamber containing a continuous sparking plug which fires the charge and, lastly, the emission of the exhaust gases (cp. Fig. 13 and discussion in a later part of this abstract).

This takes care only of two phases of the four-cycle system, namely, combustion and exhaust; and the experimental model receives its charge from an extraneous source, but it is intended to introduce a three-skew gear wheel into the train in order to provide for induction and compression within the turbine itself. No reciprocating parts or valves are necessary.

Fig. 11 gives a series of three diagrams, each of which shows a drum having a diagonal groove cut across its periphery. This groove forms three out of four walls of a rectangular-section "cylinder," the fourth wall being provided by a stationary casing or shroud around the drum not shown in the sketch. Within the cylinder groove appears a black diamond representing a piston free to move only in the direction of the dotted center line. The rotation of the drum in the direction of the arrow will cause the piston to travel across the face of the periphery, so that in moving from one side to the other it will travel down the length of the groove. If the drum be regarded as one skew gear wheel and the piston as one tooth on the periphery of a slice of a skew gear wheel, the principle of the turbine becomes clear.

Fig. 12 will help to understand it. It shows in the upper part between two teeth of one skew gear the groove forming a cylinder in which can be seen a piston consisting of a tooth broken off from the periphery of the thin skew gear shown in the lower part

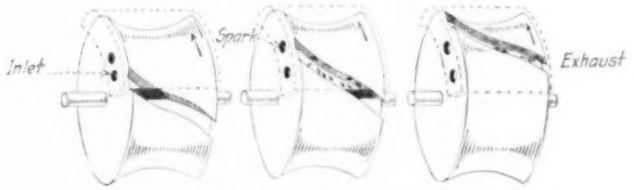

FIG. 13 THREE POSITIONS OF THE PISTON TOOTH AND CYLINDER GROOVE IN THE SANDERS TURBINE RELATIVE TO PORTS IN THE SHROUD AT THE MOMENTS OF GAS ADMISSION, FIRING AND EXHAUST

of the same figure. As the two gears shown in the figure are approximately correct in shape, it may be noted that the teeth of the "cylinder wheel" are not flat, but are hollowed with radii struck from the center of the "piston wheel" after the fashion of

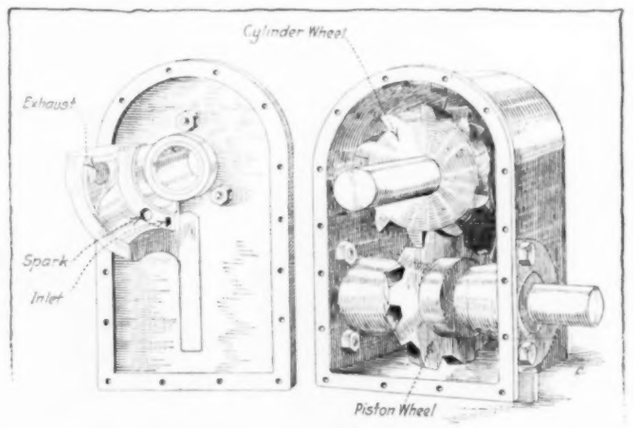

FIG. 14 INTERIOR OF SANDERS EXPERIMENTAL TURBINE (*right*) AND INTERIOR OF THE COVER AND SHROUD WHICH FITS INTO THE HOLLOWED PERIPHERY OF THE TOP ROTOR OR CYLINDER WHEEL (*left*)

the Lanchester worm gear, which, with the slice form of piston, avoids the usual helical-gear clearance formulæ. This is, of course, essential to the turbine gearing, as the "piston-wheel" teeth must keep a gastight contact with the "cylinder-wheel" gears during the whole time of their meshing.

It is stated further that the piston wheel is purely an idler, and is not called upon to transmit any torque. Furthermore, when the

device is running, both the cylinder and the piston are in motion.

Fig. 13 shows the sequence of events in the power cycle. In this figure the periphery of the drum is hollowed out to the actual shape and the groove is given a semblance of its correct form.

In the first of these diagrams the left-hand end of a cylinder groove, after its piston has just entered, is opposite the inlet through which gas mixture under pressure is entering. Further rotation of the cylinder groove causes the latter to pass by and cut off the inlet, then to uncover the second port in which a constant spark is taking place. This position is shown in the second diagram. The explosion takes place, and the cylinder groove, after further rotation, is deserted by the piston and the exhaust gases are free to escape as in the third diagram.

The following are given as trial runs of the experimental model.

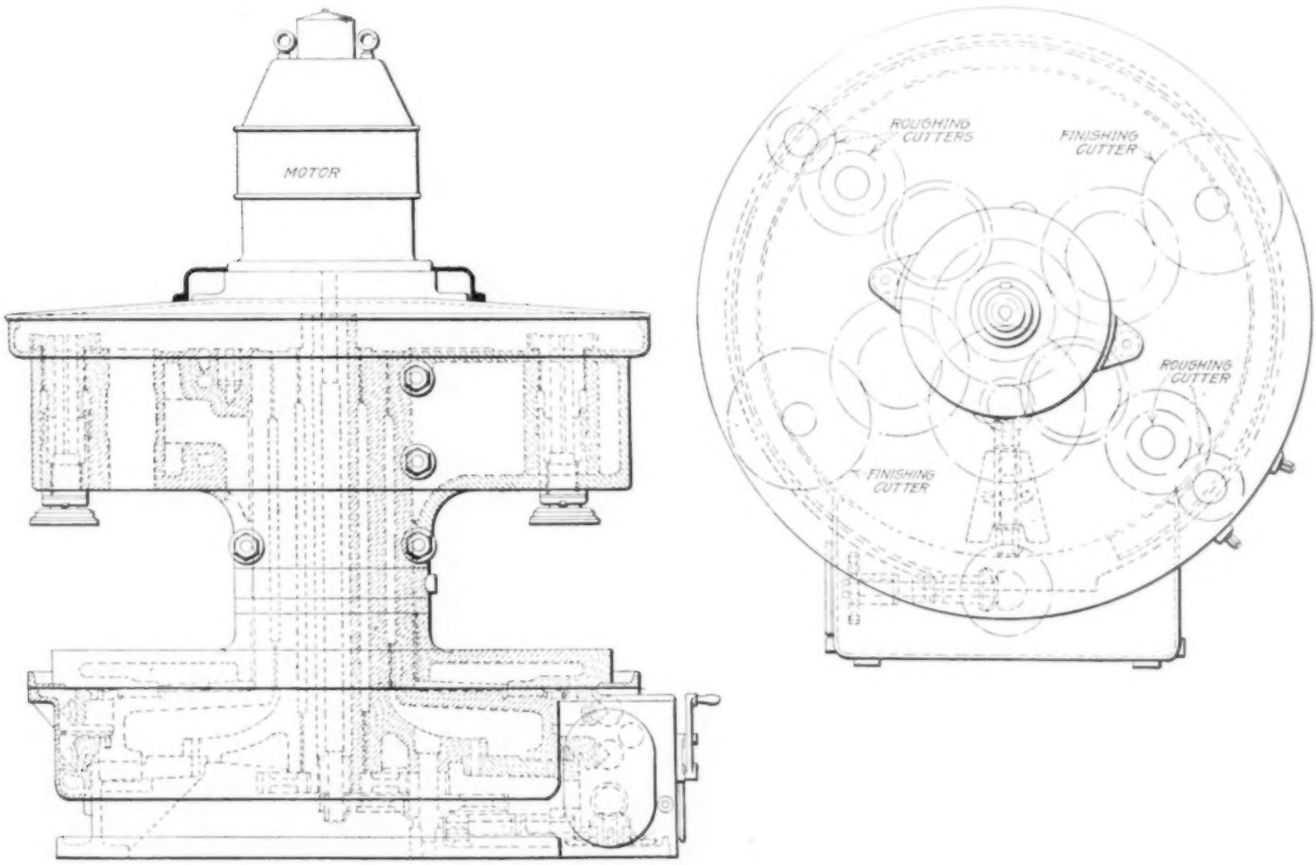

FIG. 15 INGERSOLL DIFFERENTIAL-TYPE CONTINUOUS MILLING MACHINE (SECTIONAL VIEW OF THE MAIN WORKING PARTS)

Air pressure at 40 to 50 lb. per sq. in. was obtained from an outside compressor and the air before being drawn into the compressor obtains the necessary amount of gasoline in its passage through the carburetor. When the air compressor was turned on to the turbine the latter maintained a speed of about 1000 r.p.m. The instant, however, that the ignition was switched on the speed jumped to 4000 revolutions, accompanied by a roar of explosions from the exhaust pipe. No brake-horsepower tests were performed in the presence of the author.

For cooling, a small power blower passed a blast of cool air directly on the grooved wheel.

In the article is included a report by W. Morgan, professor of automobile engineering, University of Bristol, in which it is estimated that a unit with the 5.5-in. cylinder wheel and two piston wheels should be capable of developing 36 hp. at a speed of 10,000 r.p.m., and it is believed that far higher speeds are possible.

In view of these statements Fig. 14, showing the interior of the Sanders experimental turbine, may be of interst. (*The Autocar*, vol. 43, no. 1245, August 30, 1919, pp. 317-320, 8 figs., *d*)

HEAVY-FUEL CARBURETOR-TYPE ENGINES FOR VEHICLES, J. H. Hunt. The article discusses the combustion of heavy fuels, meaning thereby fuels of higher vaporization point than gasoline in engines of constant-volume type, and calls attention to two important facts:

First, the problems of carburation and distribution can hardly be separated. Further, when the mixture finally reaches the cylinder the heavy fuels do not burn in the same manner as the lighter hydrocarbons, and under certain conditions exceedingly severe knocking takes place. Investigation has shown that this knocking is due to the momentary existence of exceedingly high pressures in the engine.

The writer states experience has shown that it is possible to handle a wet mixture in an air-cooled, single-cylinder engine running under steady load conditions, which indicates that a high temperature in the combustion chamber will take care of the effects of previous lack of vaporization, and will tend to prevent the condensation and deposition of fuel.

On the whole, the author expresses the belief that so far no means have been shown by which the heavy-fuel carburetor engine will improve the fuel situation to any great extent. The equipments which have shown promising results in service have handled nothing heavier than kerosene, and at present only half as much so-called kerosene as gasoline is being produced. (*Journal of the Society of Automotive Engineers*, vol. 5, no. 3, September, 1919, pp. 202-207, *g*)

MACHINE TOOLS

INGERSOLL DIFFERENTIAL-TYPE CONTINUOUS MILLING MACHINE, J. V. Hunter. Description of a new machine built by the Ingersoll Milling Machine Co. of Rockford, Ill., and designed essentially for

continuous milling operations. It is so built that it may have a multitude of working stations, but has only one loading and unloading station, so that only one operator is required to control all of its motions and results.

The main parts of the new machine are (Fig. 15) the lower or work-carrying table and the head carrying the milling-cutter spindles. Both of these revolve in the same direction, which accounts for the use of the term "differential" in the name of the machine. The difference is in the relative speeds of the two parts, and it constitutes the rate of feed of the cutter across the face of the work.

Vertically through the center of these two revolving parts is a large column about which the work table rotates and which, in its turn, carries and drives the heavy spindle head. The head carries a number of spindles, this number varying with the character of the work for which the machine has been planned, and is always one less than the number of work-holding fixtures which are carried upon the table. This permits the cutter spindles to be continuously operating at all times upon work, yet leaves one fixture idle at the loading station, which permits the operator to remove or replace work in this fixture before it travels around into a working position.

The entire upper structure or spindle head rotates toward the left of the operator as he faces the machine. The table carrying the work at the same time rotates in the same direction, but at a slightly lower rate of speed, so that the cutter spindles gain upon it at an average rate of 15 in. per min. at the average center of the work, which has been determined upon as the proper rate of feed for the job under consideration. The relative motion of the spindle head and work table are so timed that when the work table has made one complete revolution the spindle head has gained upon it a sufficient distance to carry one spindle completely across the face of the work. Because of this, normally a casting which was placed in any one fixture is, when returned to the loading station at the end of a complete revolution, entirely machined and ready for removal from the table.

The original article describes and illustrates some of the fixtures used in the machine.

The power drive is by a vertical electric motor mounted above the center of the machine. This feature permits the drive shaft to extend through the center of the column to the base below and saves floor space.

The number of the spindles on the machines so far built varies from four to seven. Regulation of the height of the spindles for the varying depths of cut is obtained by means of standard Ingersoll quills which extend through the housing near the base of a spindle. These permit the operator to alter the depth of cut at will be compensate for the wear or regrinding of any or all sets of cutters. Each spindle is provided with its individual attachment of this character.

One of the features to which particular attention is called in the original article is the absence of any necessity on the part of the operator of attending any station other than that which has been called the loading station; that is, the one where the work is put in and removed. (*American Machinist*, vol. 51, no. 14, October 2, 1919, pp. 645-650, 6 figs., *d*)

POWER PLANT ENGINEERING

ATMOSPHERIC POLLUTION FROM THE ENGINEER'S STANDPOINT, John B. C. Kershaw. The present article is based on the fourth report of the Advisory Committee attached to the Meteorological Office, dealing with the results obtained by the observations of atmospheric pollution in London, Manchester, Glasgow and other towns in the years 1917 and 1918.

An interesting point of view from which atmospheric pollution is considered is that of the degree to which it affects boiler feedwater, the opinion of the writer being that through air pollution dissolved impurities are traced into the rain water in the neighborhood of towns and cities and that ultimately this water gets into the boilers and produces quite undesirable results.

The general use of higher temperatures and pressure in steam boilers than was customary a few years ago renders it imperative that much greater care should be given to the purity of the water supply.

The data reported for the years 1917 and 1918 are compared by the writer with data previously published for pre-war use. A comparison of these data shows that there has been a nearly universal increase in the pollution of the air in the war period.

Of the materials found in rain water, tar, ash and some of the carbonaceous matter are insoluble, while other carbonaceous matter, chlorides, sulphates, ammonia and soluble ash are soluble. There have been found some variations between the amount of impurities in various English towns and also seasonal variations, the latter being particularly noticeable in the London group. (*The Engineer*, vol. 128, no. 3322, August 29, 1919, pp. 197-198, *p*)

SKIMMER IN 800-HORSEPOWER BOILER. Description of a baffle arrangement used by the Indianapolis Light and Heat Company to prevent particles of suspended matter from being carried over into the header with the steam by particles of water.

Before the skimmer was installed the company had a good deal of trouble because the feedwater was passed through water softeners and on coming out contained a quantity of suspended matter.

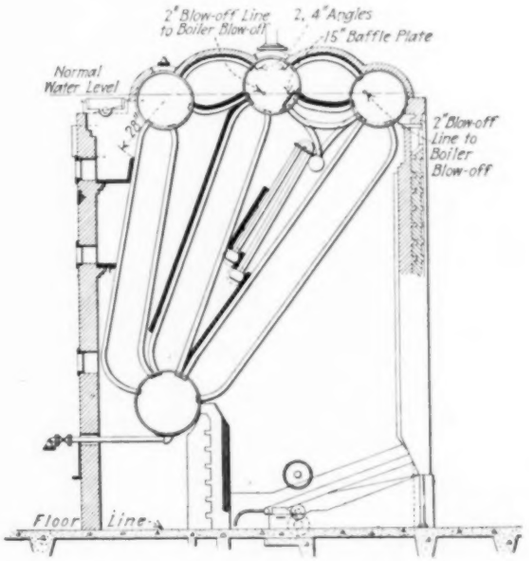

FIG. 16 BAFFLE SKIMMER FOR ELIMINATING SUSPENDED MATTER IN BOILER

When the boilers were operated at high rating particles of this suspended matter were carried over, causing a decrease in superheat and clogging up the lines and turbine blading.

The arrangement adopted is shown in Fig. 16. Two 4 x 4 in. angle irons were placed lengthwise in the middle steam drum, just above the steam-circulating tubes. In addition to this one No. 12 sheet-iron baffle 15 in. wide was installed lengthwise in the middle steam drum. It is 14.5 ft. long, and so located that it breaks the force of the water entering from the front drum, while the other angle irons check the upward rotation of water within the drum.

A 2-in. blow-off line is installed just below the normal water line in both the middle steam drum and the front drum. These blow-off lines run the length of the drum and are led into the boiler blow-off lines, valves being provided for their control.

It is stated that the device costs only a few dollars to install and does away entirely with the trouble previously experienced. (*Electrical World*, vol. 74, no. 11, September 13, 1919, pp. 581-582, 1 fig., *d*)

POWER TRANSMISSION

CONVERTING MACHINES TO INDIVIDUAL DRIVES. Description of methods used in converting a plant doing electrotyping on a large scale.

One make of motor and one speed (1800 r.p.m.) were used in order to realize the advantages of interchangeability and standardization, the motors being of the two-phase 220-volt type. Belt transmission between motors and driven machines was employed.

The article is of interest in that it describes in some detail and illustrates the way the various drives were installed and also gives a table showing the rating of motors driving electrotyping machines. (*Electrical World*, vol. 74, no. 12, September 20, 1919, pp. 637-640, 2 figs., *dp*)

REFRIGERATION

TEST OF A 2-TON CLOTHEL REFRIGERATING MACHINE, M. C. Stuart, Mem.Am.Soc.M.E. Data of a test recently conducted at the U.S. Naval Engineering Experiment Station at Annapolis.

The refrigerating medium in this machine is ethyl chloride, C_2H_5Cl, a neutral chemical having a boiling point of 54.5 deg. fahr. at atmospheric pressure. The unit consists of a motor-driven rotary compressor, a condenser, separator, expansion trap and brine cooler.

The construction of the rotary compressor is shown in Fig. 17. The rotor is located eccentrically in the cylinder, which is bored elliptically on a special machine. The top of the rotor makes contact with the top of the cylinder, thereby forming a seal between the suction and pressure sides of the cylinder. The blades are fitted into four slots milled radially in the rotor, and into the outer edges of the blades are fitted half-round packing strips which are machined to conform to the inside of the cylinder. The blades and packing strips are held out by spacing pins which pass through the center of the shaft. The seal between blade and cylinder wall is therefore positive, and contact between blade and cylinder wall does not depend upon springs or upon centrifugal force acting on the blades. The rotor is keyed to the steel shaft, which is carried on ball bearings mounted in the cylinder heads. The apparatus is lubricated by chemically pure glycerine passed through a glycerine strainer.

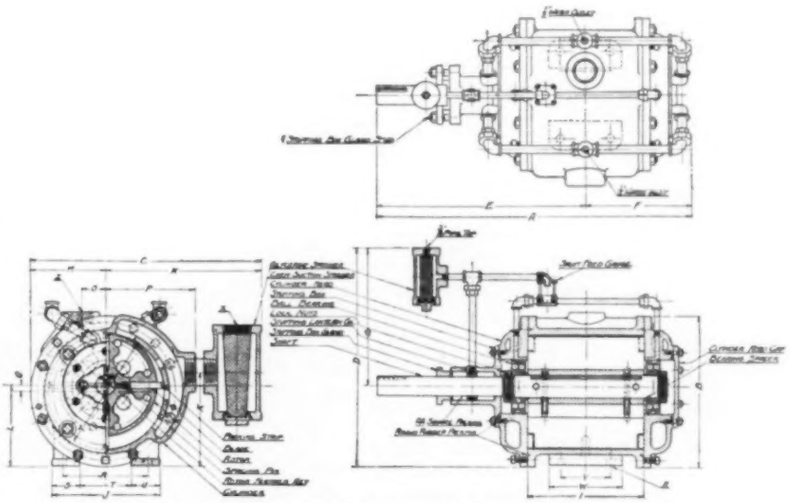

FIG. 17 ROTOR COMPRESSOR OF THE CLOTHEL REFRIGERATING MACHINE

The original article shows the arrangement of the refrigerating apparatus. From the compressor the refrigerant in the form of gas flows to the condenser, this latter consisting of U-tubes arranged in two passes with condensing water flowing through the tubes. After being condensed the liquid refrigerant, together with the lubricant, flows into the separator where the lubricant, being heavier than the refrigerant, is drained back to the compressor and the liquid refrigerant is led to the expansion trap. From there the refrigerant passes to the brine cooler, the construction of which is similar to that of the condenser, the refrigerant being in the shell and the brine passing through U-tubes arranged in two passes. In the brine cooler the refrigerant is vaporized by the heat which is abstracted from the brine and in the form of a vapor passes to the compressor where the cycle of operations starts over again.

The principal results obtained on the test are given in a table, from which it appears that the refrigerating effect is increased with higher brine temperatures and lower circulating water temperatures. With a circulating water temperature of 70.1 deg. fahr. and a brine temperature of 14.57 deg. fahr. the net refrigerating effect was 2.13 tons per day. (*Journal of the American Society of Naval Engineers*, vol. 31, no. 3, August 1919, pp. 624-634, 6 figs., *dt*)

Testing and Measurements

NOTCHED-BAR TESTS, Dr. W. C. Unwin. Discussion of some of the questions bearing on the subject of the title of the article, with special reference to the Report of the Committee on Impact Tests of the British Association (Report for 1918, page 17 et seq.)

On the basis of this report, and other data, the author points out that the results of tests on a given material vary with the size of the test bar. Because of this, if notched-bar tests could always be made on bars of the same dimensions the work of fracture per square centimeter of the section of the notch would be a sufficient practical guide to the quality of the material; but actually it is not possible to test different materials in different cases with bars of uniform size, which makes the results not directly comparable.

Furthermore, the author shows that the work of rupture is not proportional to the volume of the bar. The ratio of the resistance of different sizes is up to the present undetermined and tests on bars of different sizes cannot be compared. In this connection the writer complains that the ratios of kilogram-meters per square centimeter obtained for different materials for each pair of testing machines are so divergent in published report of tests, including the British Association report, that often it is impossible to make anything out of them.

Quoting the empirical formula of reduction for notched-bar tests given by Charpy and Thenard, the author adds the following:

"It has been remarked that an empirical formula which agreed with a series of experimental results, might give some indication of the direction in which a rational law should be sought. It has been alleged that the constant required in reducing the notched-bar tests must have the dimensions of work divided by volume. Now, Charpy and Thenard's bars were geometrically similar, and if the above statement is true, the work of rupture should be proportional to the cube of homologous dimensions, or to $a^{1.5}$. According to the tests, this does not seem to be the case." (*Engineering*, vol. 108, mp. 2802, September 12, 1919, pp. 329-320, *tA*)

CLASSIFICATION OF ARTICLES

Articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of especial merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society.

A bill has recently been proposed in the United States Senate whereby jurisdiction is extended to the several courts of the United States sitting in admiralty, to hear and adjudge suits for damages brought by the owner of any vessel or cargo for loss, damage or injury to property, due to the fault of any vessel owned or operated by the United States or by a corporation in which the United States is the controlling stockholder. These courts are to enter a decree in a proper case against the United States for the amount of loss, damage or injury, together with interest at four per cent and costs.

MECHANICAL ENGINEERING

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Contributions of interest to the profession are solicited. Communications should be addressed to the Editor.

As already announced to the readers of MECHANICAL ENGINEERING, the printers' strike in New York has closed all the union printing plants of the city, the daily newspapers excepted, and has resulted in a complete tieup of the printing industry in this, the largest publishing center of the country. In this emergency MECHANICAL ENGINEERING is being printed temporarily in another city, but will not arrange for permanent publication outside of New York unless a situation develops not yet anticipated.

As the most practical method of handling its publication, the "Society Affairs" material for November, usually contained in Section Two of MECHANICAL ENGINEERING, was printed separately in a third place and mailed to the entire A.S.M.E. membership and to the subscription list early in the month, in order to give prompt service to those interested in the Employment Bulletin and in Society announcements. Following this the Technical Section is now issued at as early a date as could be arranged, and, although curtailed somewhat in extent and variety of contents, brings to its readers a selection of the papers to be presented at the Annual Meeting of the A.S.M.E., together with the usual Engineering Survey, Engineering Index and miscellaneous matter.

Congratulations to Western Society of Engineers

The Western Society of Engineers, with headquarters at Chicago, has just completed a successful drive for membership, resulting in 2000 new members. One hundred and fifty workers were enlisted to put the drive across, divided into ten teams, each with a captain and nine solicitors. That there might be no duplication, each team was given a definite list of names to work upon. There was the greatest rivalry between teams and enthusiasm was manifest throughout the undertaking.

The Western Society was organized in 1869, and though mainly devoted to the interests of one section of the country, as designated by its name, it actually has a membership throughout the nation and in several foreign countries. The engineers of Chicago are fortunate in having so strong and long-established a body through which to coördinate their interests, and the society is to be warmly congratulated on this, its fiftieth anniversary.

Mid-West Sections Meeting of The American Society of Mechanical Engineers

An innovation in the development of the sections' activities of The American Society of Mechanical Engineers was carried out at Indianapolis on October 24 and 25 when the members of the Society gathered for a two days' session under the direction of eight sections of the Society. The Indianapolis Section handled all of the details for the social side of the program, and the seven other sections were invited to contribute papers to the professional program. This secured a wealth of papers on the two topics covered by the meeting, the first of which was devoted to Industrial Unrest and the other to Research.

Recognizing the importance of meetings of this kind in the development of the Society, the Council contributed by holding its October meeting at Indianapolis and participated in several features of the program.

At the opening session Friday afternoon, Dean Charles Russ Richards, of the University of Illinois, presided. W. C. Rogers, Manager of the Employers' Association of St. Louis, opened a discussion on Industrial Unrest, with an analysis of the causes and remedies for the existing conditions. Adequate wages for employees, adoption of measures for their health and for recreational facilities, and the Americanization of foreigners, among other points, were urged by Mr. Rogers.

A paper prepared by C. F. Scribner, consulting engineer of Chicago, was presented by Arthur L. Rice, Chairman of the Chicago Section. It urged that the piece-work system be placed in operation only after thorough investigation to determine a just scale and to insure that rates would not be revised without a change in the conditions forming the basis on which they were first established.

Results of the Americanization Program Carried Out by the Commonwealth Edison Company of Chicago was the title of a paper presented by A. D. Bailey, Assistant Chief Engineer of that Company, who discussed the Americanization of foreigners by means of primary education in our language and methods of government.

Dean J. A. Watkins, Director of the Department of Industrial Medicine of the University of Cincinnati, described the work undertaken in the study of industrial disease.

Intensive Manufacturing Methods, together with the Proper Training of Men toward Organization, was the text of an illustrated address by Prof. B. W. Benedict, Manager of the Shop Laboratories of the University of Illinois.

Following a banquet in the evening, Charles F. Coffin, President of the Indianapolis Chamber of Commerce, welcomed the visitors and Dean M. E. Cooley, President of The American Society of Mechanical Engineers, responded. After this an unique and interesting address was given by Dr. Willis A. Moore of Detroit, Mich., who is now devoting his time to addressing the workers in various manufacturing plants, inculcating a spirit of true Americanism, a desire for closer relationship between capital and labor and an understanding of the reasons why increased production is essential at the present time. Dr. Moore stripped off his coat and collar, actually, not figuratively, and made his talk a realistic reproduction of a noon-day shop meeting, such as he addresses from day to day.

The session on Research, at which Prof. Arthur M. Greene, Jr., presided, brought forth a number of excellent papers.

C. F. Hirshfield, Director of the Research Department of the Detroit Edison Company, opened the session with a statement of the Present Status of Research in the Industrial Life of the Country, and pointed out the necessity of the attention to the problems of finance, distribution and utilization of products, as one means of stabilizing industrial conditions.

The Administration of Industrial Research Affairs was presented by R. E. Carpenter, Director of the Research Department, Aluminum Castings Company of Cleveland.

L. G. Robinson, of Cincinnati, spoke on Coöperative Industrial Research and Dr. E. P. Hyde, Director of the Nela Park Laboratories, described the work done there.

A paper on the Fatigue of Metals Phenomena was read by Prof. H. F. Moore, of the University of Illinois, who had with him a reel, showing by motion pictures in detail the effect of stress of steel.

Dean C. H. Benjamin described the tractor testing plant at Purdue University and Mr. L. C. Nordmeyer read a paper on Research, prepared by W. G. Hessenbruch of St. Louis.

Dean J. R. Allen, Director of Research for the American Society of Heating and Ventilating Engineers, completed the program with a paper on Pure Science and Engineering Research.

At the completion of the professional portion of the program the members enjoyed an automobile trip to the Indianapolis Canoe Club for luncheon, going later to the Aviation Repair Depot and the speedway flying field, where exhibition flights were made.

Transactions of the A. S. M. E.

Volume 40 of the Transactions of The American Society of Mechanical Engineers has been issued to the membership. The volume comprises forty-four papers and discussions on a wide variety of mechanical engineering and industrial economic subjects; two reports by committees of the Society—one on the metric system and export trade and the other on the standardization of flanges and pipe fittings; and a comprehensive symposium on the economical use of fuel, occupying practically one-sixth of the book and forming a consensus of the experience of a large number of engineers, contributed in the interests of the national fuel-conservation program. A number of the industrial papers relate to problems brought to the fore by the exigencies of the war.

One group of papers deals with thread gages and with the work thereon of the British Engineering Standards Association, while another takes up problems involved in the employment of labor. Other subjects considered in the remaining papers are management, power-plant topics, aeronautics, weights and measures, foundry costs and accounting, factory construction, internal-combustion engines, refrigeration, mechanics, textiles, etc.

The preparation of the volume has been carefully supervised by the Publication Committee of the Society, and special pains have been taken in the selection, arrangement and indexing of the material to make it of the greatest possible reference value.

The American Air Race

During the month, as part of the experimental program carried on by the War Department, an air race was conducted between Mineola, Long Island, and San Francisco, the conditions of the race being that each of the fliers had to start from and get back to one of these terminal points. Only military fliers were permitted to participate, various machines, American and foreign, being used.

Although at this writing only fragmentary data are available, a few facts nevertheless stand out. Several fliers have completed the circuit either from Mineola to San Francisco and back, or from San Francisco to Mineola and back, which shows that machines can be built to stand a 7000-mile trip under comparatively unfavorable weather conditions.

Another lesson of the flight is the apparent unsuitability of the DeHaviland-4 machine for long-distance flying and its lack of safety. In several accidents pilots were killed under conditions which indicated that had the accident occurred in a different machine, such as, for example, the DeHaviland-9, the pilots might have escaped with only minor injuries.

The most important and, to those who are familiar with the conditions of aviation service in this country, by no means unexpected lesson of the flight lies in its showing once more the high average of the human material in the service. The flight took place under more than usually unfavorable weather conditions. The qualities of the machines were well-known. There were no great prizes offered, and the men flew and took great and well-recognized risks, simply as part of the day's work. The large number of men who volunteered for the race showed a quite exceptional average of skill under very adverse conditions.

There is no question but that the American army possesses as fine human material for the upbuilding of its flying branch as could be desired, and it only needs that the mechanical equipment of the service be brought to the same standard.

The Engineering Index for 1919

Although the annual volume of the Engineering Index has heretofor been based upon the classified system, it has long been the opinion of many who use the index that a strictly alphabetical arrangement would greatly enhance the value of the volume. Accordingly the items which form the 1919 Engineering Index will be alphabetically arranged, with liberal cross-references provided.

The 1919 Index, published by the American Society of Mechanical Engineers, will be a volume of approximately 500 pages and will contain over 12,000 references to engineering literature of the current year. These references have been selected from over 1100 periodicals which are regularly received by the library of the United Engineering Societies, and which represent the leading literature of the engineering profession both in this country and abroad.

On account of the difficulties in the printing industry, no definite announcement can as yet be made concerning the date of publication, but it is hoped that the book will make its appearance early in the coming year, and as soon as possible further details will be announced.

Dedication of Pittsburgh Station Bureau of Mines

The new buildings of the Pittsburgh Station, U. S. Bureau of Mines, were formally dedicated on September 29 and 30, and October 1, under the auspices of the U. S. Government, the State of Pennsylvania and the city of Pittsburgh, the Chamber of Commerce coöperating.

The station at Pittsburgh, with its spacious buildings, its museum, and its many laboratories and offices, is the largest of the eleven experiment stations of the Bureau distributed throughout the country, and is of particular interest to mechanical engineers because of its fuel laboratory, constituting as it does one of the two Government laboratories for the investigation of mechanical engineering problems, the other one being the Naval Experiment Station at Annapolis. This, of course, is excluding the specialized work of the Government in aircraft and in connection with the physical laboratories at the Bureau of Standards.

While the Bureau of Mines is engaged primarily in mining problems, and particularly those relating to mine safety, a large and important part of its work is concerned with the problem of obtaining greater efficiency in the burning of coal. The Bureau has been the pioneer in combustion experiments in the United States and has issued many reports on this subject familiar to engineers.

The fuel laboratory at Pittsburgh is splendidly equipped and more apparatus of commercial size will be added in the near future. Extended experiments in the transmission of heat through boiler tubes and furnace walls are under way, and it is here that the research work lately instituted by the American Society of Heating and Ventilating Engineers is to be conducted with respect to systems of heating, radiation constants, air standards based on humidity, etc.

At the dedication of the Pittsburgh buildings there were opening exercises at which Governor Sproul of Pennsylvania was the principal speaker; a reception by Dr. Manning, Director of the Bureau of Mines, and Mrs. Manning; a pageant glorifying the mining industry; and a dinner given by the Chamber of Commerce. During the three days of the celebration demonstrations were made of coal-dust explosions and there were mine-rescue and first-aid contests by teams from different states.

TECHNICAL PAPERS TO BE PRESENTED AT THE A. S. M. E. ANNUAL MEETING

IN this and the last number have been printed extended abstracts of several of the papers to be presented at the coming Annual Meeting of the A.S.M.E., and there are given below very brief summaries of a larger list of these papers than it has been possible to incorporate in these two last numbers of MECHANICAL ENGINEERING. These papers are available in pamphlet form for distribution to the members of the Society in advance of the meeting, which occurs December 2 to 5. Members wishing copies should notify the Secretary of the particular papers desired and pamplets will be forwarded promptly.

COMMON ERRORS IN DESIGNING AND MACHINING BEARINGS, by Christopher H. Bierbaum. In this paper the author discusses such matters as oil grooves and their proper distribution, the disadvantages of tight-fitting bushings, proper methods of finishing brasses to provide for expansion when running, and proper methods of clamping bearings while they are being machined. He also shows by means of photomicrographs of finished surfaces the importance of using sharp tools with the proper rake in order that the crystalline structure of the surface material of the bearing may not be so crushed and compacted that it will fail to function as a normal bearing alloy.

TURBO-COMPRESSOR CALCULATIONS, by Allen H. Blaisdell. A paper dealing at length with the thermodynamic and pneumatic principles involved in the operation of a turbo-compressor, and including in its treatment a study of the nature of compression, and the layout of a compression diagram, the theory of fluid flow, essentials of impeller and diffuser design, and considerations regarding power consumption and efficiency.

THE HVID ENGINE AND ITS RELATION TO THE FUEL PROBLEM, by E. B. Blakely. This paper describes a type of engine, the Hvid, which it is claimed has all the advantages and none of the disadvantages of the so-called Diesel type, and which is being produced in units as small as 1½ hp. It can be started cold. It has no complicated air-compressor systems and is said to be so economical that it can compete with gasoline engines of the same size. The author outlines the operation of the engine, describing in detail the suction, compression, power, and exhaust strokes, and presenting a series of indicator cards. Fuel consumption is shown by means of a series of curves obtained as the results of tests performed. The paper concludes with a discussion of the heat balance and torque characteristics of the engine. It is pointed out that there are certain characteristics of the engine which ought to attract internal-combustion engineers to its study to the end, perhaps, of perfecting it and thus assisting in solving some of our fuel problems.

EMERGENCY FLEET CORPORATION WATER-TUBE BOILER FOR WOOD SHIPS, by F. W. Dean and Henry Kreisinger. This paper describes tests upon the standardized water-tube marine boiler designed by the United States Shipping Board, Emergency Fleet Corporation. Of the 1352 ordered, the first 706 were alike. The other 646 were ordered with slight changes including the use of four passes instead of three passes embodied in the original lot. In view of the large number of boilers needed, the scarcity of steel and the desire to secure competitive prices, the water-tube type was adopted instead of the Scotch marine type. This made it possible to have the boilers constructed in inland shops throughout the country and effected a reduction in the weight of steel of more than 9,000,000 lb. for the total order. The boilers had a grate area of 65.54 sq. ft., heating surface of 2500 sq. ft. and a commercial hp. of 435 on the basis of the marine rating of 6 lb. of water to a sq. ft. of heating surface per hour. Under test the three-pass type showed at first an efficiency of 60 per cent which was later raised to about 73 per cent, based upon combustible, by certain changes which were effected. The four-pass type exceeded 74 per cent on two tests. These results were obtained when the boilers were hand-fired. Subsequently an investigation was made by Mr. Henry Kreisinger of the Bureau of Mines of the mixture of air and combustible in the furnace and of the temperature of the gases, details of which are given in the text together with tables showing the complete results of the evaporative tests.

FLOW OF WATER THROUGH CONDENSER TUBES, by William L DeBaufre and Milton C. Stuart. This paper is the result of a series of tests which were conducted at the United States Naval Engineering Experiment Station at Annapolis, Md., to determine the friction loss of water flowing through ⅝-in. standard condenser tubes of No. 18 gage. The investigations covered variable velocities, water temperatures, and tube length, as well as the effect of both fresh and salt water. The computations were made in such a manner that the various losses could be separated and the results have been expressed in a general formula.

WAGE PAYMENT, by A. L. DeLeeuw. A paper which discusses the various items entering into the present relations between employer and employee. The author first calls attention to the fact that some of the terms which are most commonly used are not clearly understood. Among these are "capital," "labor," "right to organize," "collective bargaining," and "wage." He accordingly discusses each, and then takes up the subject of the various systems of payment in existence at the present time. Taking the aims of the organized labor to be: (1) proper share of the proceeds of labor, (2) reasonable working conditions and working hours, (3) right to organize, and (4) collective bargaining, the author believes that these aims could all be accomplished without strife if collective bargaining were put into actual practice instead of being a mere catch word. In conclusion he states that in his opinion the real cause of the current unrest lies in the fact that our present wage system is not based on knowledge and justice, but only on guess work and on the fear that the one of the parties concerned may "do" the other.

SLOW-SPEED AND OTHER TESTS OF KINGSBURY THRUST BEARINGS, by H. A. S. Howarth. This paper presents operating and experimental data which show the wide range of application of the Kingsbury thrust bearings. The author describes typical installations of bearings which have been in successful operation since 1911. The Kingsbury thrust bearings have been applied to vertical and horizontal hydroelectric units, to horizontal steam turbines and to centrifugal pumps, and to determine some of the service conditions, a series of slow-speed tests were made, details of which the author presents in his paper. The results of these tests indicate that the lower the speed at which the bearing is run continuously, the better the conditions of bearing surfaces. Speeds as low as 0.38 r.p.m. have thus far been employed, using, however, only a light oil.

A PERFECTED HIGH-PRESSURE ROTARY COMPRESSOR, by Chester B. Lord. A paper giving particulars of an improved rotary compressor of the eccentric-rotor and telescopic-blade type, in which leakage, friction, and packing troubles have been overcome to such an extent that a volumetric efficiency of 92 per cent at seven compressions (100 lb. per sq. in.) is said to be commercially obtainable. This compressor, it is stated, will handle gas, air or liquid, or all three, without adjustment or alteration, and a single-stage machine will compress to a pressure of 500 lb. per sq. in.; further, it is possible to compress to 1000 lb. in three stages with the three units on the same shaft.

MODERN ELECTRIC-FURNACE PRACTICE AS RELATED TO FOUNDRIES IN PARTICULAR, by W. E. Moore. In this paper the author, after first giving particulars regarding the operation of acid and basic furnaces, enumerates the superior properties of electric steel, and the advantages of the electric furnace over the open-hearth method. Crucible and converter processes are next briefly mentioned, the author pointing out the superior characteristics of the acid type of furnace for foundry work. To set forth the marked economy of the electric furnace, comparative operating costs of producing liquid steel both by the converter and the electric-furnace process are given, and the paper concludes with notes on the use of the electric furnace in malleable-iron foundries and on the selection of the most suitable type of furnace for a given installation.

SCIENTIFIC DEVELOPMENT OF THE STEAM LOCOMOTIVE, by John E. Muhlfeld. Although marked progress has been made in the development of the steam locomotive and the results have been in many respects exceedingly effective, they have, nevertheless, been largely confined to assisting in improving sustained boiler capacity and increased thermal efficiency. There is, therefore, still considerable opportunity for further improvement, and this paper is a discussion of the various factors incidental to the design and construction of locomotives. Such matters as purification of boiler feedwater, use of various grades and types of fuel, heat losses, steam generation and superheating, steam distribution and utilization, and wasted heat are accordingly considered. The author also discusses acceleration and deceleration of a locomotive, and the power required for accessories such as air-brakes, signals, train lighting, heating, ventilating, etc.

AN INVESTIGATION OF STRAINS IN THE ROLLING OF METAL, by Alfred Musso. This paper is a discussion of one of the most important problems incidental to rolling-mill operation. In such mills, while raw stock is being transformed, a certain amount of material is wasted, and to determine the factors involved in this waste, the author asks and answers this question: "What is the most convenient length and width of the piece of metal to be rolled in order to produce a finished article of certain definite dimensions so that the waste of material may be reduced to a minimum?" The answer, which forms the body of the paper, is based on data secured as a result of actual investigation.

A NEW TYPE OF HYDRAULIC-TURBINE RUNNER, by Forrest Nagler. This paper is in the nature of a preliminary announcement describing the development of a new type of water-wheel runner, which it is ex-

pected will largely supplant the well-known mixed-flow reaction type. The first part of the paper is devoted to an explanation of the term "characteristic speed," which, while in the nature of a repetition of much more extensive articles previously written, is nevertheless thought to be desirable because of its peculiar adaptability to water-wheel analysis. A brief history of water-wheel development is next presented, which indicates that for nearly one hundred years characteristic speeds were gradually increased from 20 to 100, whereas the new form of runner reaches characteristic speeds averaging 150. The paper concludes with a short statement of the advantages and field of application of the new type of runner.

APPRAISAL AND VALUATION METHODS, by David H. Ray. The author holds that appraisal and valuation are essentially engineering functions, and that it is the duty of the engineer to develop, guide and control the method and procedure employed. He pointed out that the variables affecting values depend on labor, material and an aleatory factor to cover the general risk of the business, with particular reference to marketing. Charts, curves and tabulations are given to show the change in these values during the period of the war, and terms used in appraisal work are defined. The author also directs attention to the desirability of giving a value to a machine as a unit, of the grouping of similar tools, and of the use of symbols in the form of numbers and letters in tagging the materials to be appraised.

KEROSENE AS A FUEL FOR HIGH-SPEED ENGINES, by Lawrence F. Seaton. Despite the fact that considerable work has been done toward the use of kerosene as a fuel for internal-combustion engines, there still remain many unsolved problems. To study these the author accordingly made a series of tests on a high-speed, heavy-duty-type of engine, using kerosene as a fuel, and these tests form the basis of his paper. The apparatus used and the manner of conducting the tests are described in detail, and as a result of his work the author states that in his opinion a kerosene engine would be successful if designed so that the piston displacement were higher than that commonly used, if the intake passages were larger and shorter, and if the incoming gases were heated to a temperature considerably above that of the boiling point of kerosene.

OIL PIPE LINES, by S. A. Sulentic. This paper compares the cost of pipe-line transportation of oil with that of rail and canal. It also points out the advantages of the oil engine as a means of economically transporting oil for a long distance through pipes, and derives formulæ by means of which one may calculate the pressure, net horsepower, and brake horsepower necessary to transmit any quantity of oil through a pipe of known diameter.

THE THERMAL CONDUCTIVITY OF INSULATING AND OTHER MATERIALS, by T. S. Taylor. Although numerous experimenters have been interested in making thermal-conductivity measurements, but very few data are available for such materials as are used in the construction of electrical machinery. To further investigate this field, the author accordingly conducted a series of tests based upon two methods, both of which he explains in detail. The results obtained are tabulated for such materials as fish paper, fuller board, cambric, mica tape, various kinds of woods, asbestos, plate glass, sheet steel, wool felt, etc.

THE LUBRICATION OF BALL BEARINGS, by H. R. Trotter. Ball-bearing lubrication is a subject of which little is known, and this is chiefly due to the fact that there is no accepted method of determining the lubricating value of an oil or grease. As a step toward the development of a satisfactory method the author has devised an instrument for such a purpose, a brief description of which is given in his paper. The operating characteristics of a ball bearing as related to the problem of lubrication are also discussed and the specifications for a satisfactory oil are given. The use of grease and graphite as a lubricant is also briefly considered and the paper concludes with a suggested procedure for the analysis of lime-soap greases.

THREAD FORMS FOR WORMS AND HOBS, by B. F. Waterman. The use of worm gearing is steadily increasing and accompanying it, perhaps its cause, is a corresponding increase in efficiency and durability. This is doubtless the result of a better understanding of both the theoretical and mechanical problems involved, some of which the author points out in his paper. The author also suggests methods for bringing about a uniform and satisfactory practice in worm gearing.

AIR PUMPS FOR CONDENSING EQUIPMENT, by Frank R. Wheeler. This paper is devoted to a consideration of past and current practice in air-pump design and selection. After presenting a classification of air pumps the author proceeds to briefly describe the features of each type, stating their limitations and respective advantages and disadvantages. Special attention is given to the steam-jet ejector type of pump, whose advantages are stated to be: extreme simplicity, reliability and flexibility, stability, minimum space and weight, low steam consumption and high efficiency; and furthermore that it requires no maintenance or attention. The author concludes his paper by taking up the matter of selecting an air pump of proper size and capacity for a given condenser installation, accompanying his discussion with illustrative calculations and charts.

OCTAVAL NOTATION AND THE MEASUREMENT OF BINARY INCH FRACTIONS, by Alfred Watkins. This paper is an argument for the adoption of a system for measuring the binary inch fractions. At present there are two systems; one which divides the unit into halves, quarters and eighths, etc., and the other which makes use of a decimal notation. The author proposes to replace these by an octaval notation in which eight is to be used as the radix. He accordingly first presents the method of constructing such a notation, this being followed by a description of various types of rules, calipers and micrometers based upon it. It is not to be inferred, however, that the author proposes the substitution of octavals for decimals in all branches of engineering work, but he does advocate their use to denote the British binary inch fractions in the workshop and on workshop measuring instruments.

MOTOR-TRANSPORT VEHICLES FOR THE UNITED STATES ARMY, by John Younger. This paper contains a discussion of the types of vehicle best adapted to various military needs. Motor-transport vehicles have been classified by the United States Army under ten broad heads, ranging from the small 250-lb. motorcycle to the 5-ton truck. The classification has been found to be a most satisfactory one, and the ultimate ideal, of course, is to standardize the single type of vehicle for each class. With that point in view the author discusses the various vehicles used, giving in connection therewith numerous photographs as illustrative of American design and construction. Tables and characteristic torque curves are appended to the paper, and these afford a comparison of the specifications of both commercial and specially designed Government trucks and vehicles.

OCTAVAL NOTATION IN SHOP MEASUREMENTS

(*Continued from page 871*)

SIMPLIFICATIONS IN MEASURING "LIMITS"

The fact that all the standard binary fractions are expressed in the first two places of octavals, and that all the limit allowances and tolerances come in the next (3d and 4th) octaval places gives a new and unexpected value to octaval notation. The workman sets his standard size on two scales of the calipers or micrometers, and the plus or minus allowance on two different scales. No pencil or mental calculation of adding or deducting is required. Another happy fact which makes the provision of limit tables for octavals very easy, is that the third place in octavals ($_{0}001$) is $\frac{1}{512}$, and half this ($_{0}0004$) is $\frac{1}{1024}$, which is so near the much-used "thou" of the mechanic (within 2½ per cent of it) that it can safely be substituted for it in all the limit tables.

In conclusion, it should be stated that this paper is not a proposal for the substitution of octavals for decimals in all branches of engineering. It advocates their use to denote the British binary inch fractions in the workshop and on workshop precision instruments. Any use beyond this, and there are many, is for future experience. A maker adopting these in workshop practice need not bring them into his catalog until their simple logical structure is better known.

A PERFECTED HIGH PRESSURE ROTARY COMPRESSOR

(*Continued from page 878*)

The compressor may be built either vertical or horizontal and in the small sizes up to 5 cu. ft. it is air-cooled. Between this and the 15-cu. ft. size it is partly water-cooled. In the 20-cu. ft. size and above it is completely jacketed.

The advantages of the rotary compressor, all of which have been demonstrated commercially, are as follows:

1 Small weight per unit of capacity, about $\frac{1}{10}$ of that for reciprocating machines
2 Small amount of floor space required, about $\frac{1}{10}$ of that for reciprocating machines
3 Small initial cost of installation
4 Most economical drive known employed, either electric motor or steam turbine direct-connected
5 Small amount of headroom required. The machine is usually about the same size as the motor required to drive it
6 Simplicity of construction and hence small cost for adjustment or repair
7 Self-lubricating, since the entire machine operates in a bath of oil.

A MASTERPIECE OF STEEL CARVING

At a meeting of the New York Section on October 9, 1919, preceding the address of the evening, Mr. George J. Foran exhibited what he considered to be the finest modern specimens of steel carving. Mr. Foran added interest to his exhibition by his brief historical analysis of the causes which brought the art of wrought-metal work to the highest state of perfection during the golden age of Nuremberg, namely, its vital importance to the ruling classes and the insistent demand and commensurate remuneration for armor of maximum combined efficiency and beauty.

This, with the added honors bestowed upon the most successful artisians, inspired successive generations of artistic craftsmen to devote their entire life, thought, and energy to the development and perfection of the essential arts of heat treatment, hardening processes, etching, fretting, enameling, damascening, embossing, and sculptural work. Many of these arts became practically lost when the demand for this highly specialized craft ceased with the passing of armor upon the gradual practical development of firearms during the fifteenth century.

THE "FOREST SMITHY." CARVED FROM 2-IN. X 12-IN. STOCK, MILD STEEL, 18⅝-IN. LONG, BY FRANK L. KORALEWSKY OF BOSTON. WEIGHT IN THE ROUGH 127 LB., FINISHED 30 LB.

At this time Nuremberg reaped a well-earned reward for its long-continued encouragement and protection of the arts and crafts by becoming, in addition to one of the great marts of the commercial world, the center from which all great religious, scholarly and artistic movements of Germany emanated — for the reason that most of the important German scholars, artists and craftsmen had gradually been drawn to Nuremberg. These men, led by such master craftsmen as Peter Vischer, Adam Kraft and Vist Stoss, under the inspiration and example of the scholar-mathematician and artist, Albrecht Dürer, the father of German painting, turned their talents to commercial lines with great success.

The "Forest Smithy," rather inadequately reproduced in the accompanying illustration, in its subject, period, conception, perspective and execution is a perfect specimen of the old Nuremberg school. It depicts the moment when a knight, riding through a forest, discovers some trouble with his armor, and having tied his charger at the edge of the wood, is engaged in testing and bending the blade of a sword which the old smith is showing him while his assistants inside are busy at work. The smithy is the characteristic one of the Middle Ages, built upon the rough hillside in the forest to be near the charcoal supply; piles of mud and stone will be seen upon the roof to keep it from blowing off. On the road up to the castle will be seen a journeyman smith asking a village maiden the way to the smithy, which she is pointing out. The amount of undercutting and perfection of detail work can only be realized upon close inspection.

This beautiful carving was produced by Mr. Frank L. Koralewsky, of Boston, who served his apprenticeship in Germany with a firm of old-established artsmiths who adhered strictly to the best traditions of their art. After his masterpiece had been accepted and he was created a journeyman, Mr. Koralewsky spent several years traveling and working in different sections of Germany to become familiar with every branch of his art and to study the exhibited work of the early masters. He came to the United States in 1896 and settled in Boston. His work received immediate recognition and his gates will be found at Harvard, Yale and Princeton Universities, his screens at the Cathedral of St. John the Divine in New York, and fine specimens of his work in locks, handles, hinges, irons, etc., in the large public and private estates throughout the country. He received the gold medal and grand prize at the Panama Exposition for his carved wrought-iron lock illustrating the old fairy tale of "Snow White and the Seven Dwarfs."

Mr. Foran also exhibited a watch carved by Mr. Koralewsky in most wonderful detail and several smaller pieces of his work. Mr. Koralewsky executes this carved work in his spare time purely from his love of the art and always with the hope that by its exhibition other workers may be similarly inspired and the standard of the craft thus raised.

These specimens were loaned by Mr. Koralewsky to Mr. Foran for the purpose of exhibition at the different works of the Worthington Pump and Machinery Corporation. The result was most satisfactory in the way of deeply interesting the various workmen and furnishing them an outside interest for their spare time in reading the histories of the development and successes of the great craftsmen and studying the possibilities of the material upon which they work ordinarily in a purely perfunctory way.

THE JAMES WATT CENTENARY

AT the James Watt Centenary Commemoration exercises held in Birmingham, England, from September 16 to 18, there was present a notable gathering of engineers and scientists to pay tribute to this remarkable man. The Society was fortunate in being represented by three of its members, J. Wilfred Harris, H. F. L. Orcutt and J. Sanford Riley.

The program arranged by the committee was a most comprehensive one and it would be difficult to attempt to tell of the many events. Three, however, will long be remembered by those who took part in the exercises—the service at the parish church of Handsworth where James Watt was buried, the chapel of which contains the famous Chantrey sculpture of the great engineer; the visit to the garret workshop of Watt, and the inspection of one of his early engines which was put under steam for the occasion. This was the Ocker Hill engine which was built in 1776 and erected at Smethwick for pumping operations in connection with the Birmingham Canal.

The main purpose of the commemoration, however, was the raising of a fund for an international memorial. It is hoped that this will take the form of a James Watt Chair of Engineering at the University of Birmingham for the promotion of research into the fundamental principles underlying the production of power and the study of the conservation of the natural sources of energy. It is also hoped to erect a James Watt Memorial Building to serve as a museum for collecting together samples of the work of James Watt and his contemporaries, Boulton and Murdock, illustrating this interesting epoch in the history of engineering. The building would also serve as a meeting place and library for scientific and technical societies and be a center from which engineers could coöperate in spreading scientific knowledge.

In a little pamphlet issued for this occasion there appears a very interesting sketch of the career of James Watt written by Prof. F. W. Burstall of the University of Birmingham, an abstract of which follows:

The name of Watt is familiar on both sides of the Atlantic and as a hundred years have now elapsed since his death, it is possible to estimate at its true value the influence which his genius had upon the modern world.

The popular idea that Watt invented the steam engine is not correct as the Newcomen engine had been in regular use for more than a century before his discovery. Watt's work lay in the improving of an imperfect and wasteful machine, which could be employed only where fuel was cheap, into the powerful and economical steam engine with which we are all familiar. In the evolution of our modern life the steam engine has had perhaps a greater effect than any other single influence and in the development of the steam engine James Watt stands out as the great pioneer.

Watt started life as an instrument maker and was so employed by the University of Glasgow where he was led into the study of the steam engine in repairing a model of the Newcomen engine. In his experiments he learned how wasteful was the Newcomen in fuel consumption and thereupon started his study of heat properties in which he received valuable aid from the well-known Dr. Black. Watt was not long in seeing that the great defect in the Newcomen engine lay in the ejection of the condensing water into the cylinder, which led to his discovery of the separate condenser with which his name will be associated for all time.

As is usual with inventors, the years immediately following his discovery were years of trial and disappointment. Success came when the partnership was formed with Matthew Boulton, a well-known manufacturer of small metal goods in Birmingham and the founder of the famous Soho Works. He was a man of great enterprise and dauntless courage and his belief in Watt's genius never wavered throughout their connection of a quarter of a century. One other man had no small share in Watt's success and this was William Murdock who worked throughout his life at the Soho Works. His invention of gas lighting, his introduction of compressed air for power distribution and his experiments in mechanically propelled vehicles, carried out in Cornwall as early as 1785, all go to prove him a man of remarkable power.

Watt's first engines were principally used for pumping in Cornwall, where the deepening of the mines made an economical source of power essential. The first rotating engines were not produced until nearly ten years after Watt had settled in Birmingham. It was Watt's intention to use the common crank for the purpose of the conversion of reciprocating into rotary motion but in this he was forestalled by the idea's being stolen and patented, so he contented himself with the sun-and-planet motion for effecting the same purpose. The rotative engine at the Albion Flour Mills in London and another at Whitehead's Brewery, also in London, marked the beginning of the use of steam power for industrial purposes.

The use of the independent valves for the admission and exhaust of steam, the slide valve, the governor, the indicator, all took their rise in the fertile brain of James Watt, and when he left the steam engine in 1800 it possessed practically all the features with which we are today familiar.

From the year 1800 until his death in 1819 Watt withdrew entirely from business and spent his time in scientific and mechanical pursuits. In his house at Heathville Hall, near Birmingham, there is preserved intact Watt's workshop, with all his tools in good condition and practically untouched since the time when they fell from the hand of Watt himself.

In character Watt was a man of retiring and modest disposition, who made no endeavor to push himself in the public life. His last letters show his kindly disposition, in the advice which he was always ready to give to those younger than himself. All contemporary accounts of his later life speak of him with a respect almost amounting to veneration.

It would seem only fitting that a permanent memorial should be raised to the trio of pioneers who have done so much by their discoveries to advance the material happiness and prosperity of the human race. Such a memorial should be one likely to be of service to future generations, and it should make its home in the city where these three men spent their manhood, rested in their old age, where so many relics of their work are preserved and where lies all that is mortal of Watt, Boulton and Murdock.

A Plea for the Enfranchisement of Junior Members

TO THE EDITOR:

Under the provisions of the Constitution of the A.S.M.E., adopted 34 years ago, Junior members of our Society are not allowed to hold office or even to vote. The Government permits all men, and in some states all women, not only to vote, but to hold office immediately on coming of age. Our religious and social organizations are, if anything, even more liberal in this respect. Among scientific and technical societies I find the engineers are the only ones which make this age distinction. As soon as doctors or lawyers or architects are admitted to practice they are given the right to vote and hold office in their respective professional organizations. Will it be alleged that our Juniors, who in most cases have completed stiff courses in high-grade engineering schools, are less qualified to bear a responsible part in professional activities? As I pointed out in the February issue, "This class of members will always be in a hopeless minority." A Junior who joins our Society on coming of age and who later becomes eligible for full membership, spends eleven years without a vote!

Would we not be better off for having the young man's point of view? Do we not need the young man's capacity for dreaming dreams and seeing visions? When it was a matter of recruiting regiments for service in France, it was these 21-30-year olds we wanted. Have they not earned the right to full companionship in the Republic? Perhaps some one who thinks otherwise will tell us why.

MORRIS LLEWELLYN COOKE.

Philadelphia, Pa.

COMMON ERRORS IN MACHINING OF BEARINGS

(*Continued from page 880*)

tion which proved to be the sole cause for the very unsatisfactory performance which this wheel gave in service. Fig. 6 shows a magnification of part of the edge *b* of Fig. 3, the inner edge or surface of this wheel from which it is centered accurately to within a thousandth of an inch upon its spider. This surface had been tooled in a horizontal boring mill with a single cut, the tool set so as to produce a smooth finished surface. The cutting of this surface, however, was done with a tool that was sharp and had sufficient rake, showing that it is an easy matter to cut a bronze surface satisfactorily without distorting the natural orientation of its crystalline structure.

NEWS OF THE ENGINEERING SOCIETIES

Reports of Meetings of Engineering Society of Western Massachusetts, National Safety Congress, International Railway Association, and American Foundrymen's Association

Engineering Society of Western Massachusetts

The Engineering Society of Western Massachusetts met at Pittsfield on October 14, the afternoon being spent in inspecting the Pittsfield Works of the General Electric Company. After the trip through the works a dinner was held, at which there were present one hundred and twenty-three members. The principal speakers were C. C. Chesney, general manager of the Pittsfield Works; G. Faccioli, chief engineer of the Pittsfield Works; Charles H. Wright, Republican Candidate for District Attorney; Calvin W. Rice, Secretary of American Society of Mechanical Engineers; and S. W. Ashe. Mr. Faccioli spoke very interestingly regarding the problems connected with high-voltage installations. Mr. Ashe in his remarks dealt with Americanization problems at the Pittsfield Works.

National Safety Congress

The Eighth Annual Safety Congress, held in Cleveland, October 1 to 4, by the National Safety Council, was divided into sections representing the automotive, cement, chemical, structural, metal, mining, woodworking, rubber, packing, paper and pulp, and textile industries, and special sections relating to steam and electric railroads, women in industry, employees' representation, Americanization, health service, public safety, public utilities, and marine and navigation. The papers read at the sessions of the metals sections included: Accident Prevention in a Malleable Iron Foundry, by H. L. Church, Rockford, Ill.; Personal Element in a Safety Program for the Foundry, by H. F. Grantland, Marion, Ind.; New Ways to Put Safety Across in a Steel Plant, by H. P. Hoyne, Canton, O.; Humanizing a Steel Plant, by Philip Stremmel, Granite City, Ill.; and Practical Demonstration of Welding and Cutting, by J. Schleicher, Baltimore, Md. A complete collection of commercial and non-commercial safeguard appliances and devices was exhibited in connection with the congress. There were seventy booths, in which were shown types of safety equipment for every industry.

International Railway Association

The International Railway Congress Association, the foundations for which were laid at the congress convoked at Brussels in 1885 by the Belgian Government for the purpose of celebrating the fiftieth anniversary of its railways, has just been reconstituted under the title of International Railway Association. The Association published, up to 1914, a monthly bulletin containing, besides original articles upon all questions relating particularly to the technique, working and organization of railways, reproductions of the most interesting articles appearing in the railway reviews of the world, and detailed reviews of works dealing with railway affairs. At the closing sitting of the eighth session, held in Berne in 1910, it was decided that the ninth session should take place in Berlin in 1915, and the preparations for this session were far advanced in 1914 when Germany declared war and began the invasion of Belgium. Naturally the invasion of the country, and the measures taken by the occupying powers, resulted in the paralysis of activity on the part of the Association for nearly five years, but after the return of the Belgium Government, the Association was placed under sequestration, in pursuance of the Belgian law of November 10, 1918, owing to the fact that a portion of its assets belonged to the subjects of enemy nations. The sequestrator having ordered the dissolution and liquidation of the society, the railway administrations, members of the Association, belonging to thirty-five countries in and outside Europe, decided to transfer their property to an association established upon exactly the same bases as before, and entitled the International Railway Association.

American Society of Safety Engineers

At a special meeting held in the Engineering Societies Building, New York, on September 26, the American Society of Safety Engineers adopted a new constitution defining more specifically its scope in the technical engineering field and reorganizing its activities so as to include the adoption and application of safety-engineering standards, the maintenance of a library devoted to the particular requirements of safety engineering, and helpful cooperation with official and other safety organizations. The coöperation of the Society with the Bureau of Standards and The American Society of Mechanical Engineers was discussed, as well as the formulation of national safety codes on elevators, head and eye protection, and lumber and woodworking machinery.

Association of Iron and Steel Electrical Engineers

The thirteenth annual convention of the Iron and Steel Electrical Engineers was held in St. Louis, Mo., September 23 to 26. D. M. Petty, retiring president, outlined the progress made by the Association in the establishing of new sections at various cities and emphasized particularly the advantage of holding section meetings, which, he said, further the interest of the steel and iron industry by bringing together the men who are striving with the problems of increasing production, lowering costs and improving the quality of the plant product.

Of special importance were the reports of the safety and educational committees. Walter Greenwood, of the Carnegie Steel Company, Youngstown, Ohio, submitted the report of the safety committee, which comprised safety rules for the government of employees working on electrical equipment. In the report of the educational committee, presented by A. B. Holcomb, of the Standard Tin Plate Company, Canonsburg, Pa., the necessity of training electrical employees of foreign birth was strongly emphasized. Discussion of the reports of these committees brought out the suggestion that safety should be considered before tonnage in all cases, and that it is more practicable to teach men what to do than what not to do.

The report of the electric-furnace committee of the Association outlined the present status of electrical furnaces in the steel industry. The discussion brought out the insufficiency of the available technical literature on electric-furnace reactions. Concerning furnace-lining thicknesses, the opinion was expressed that too thin a lining wasted heat, while an abnormally thick lining limited the capacity of the furnace. The careful training of the operator was considered to be of paramount necessity for securing the successful operation of any electric furnace. On the question of the shape, it was stated that the furnace body should be of such shape as to give equal heat at every point.

Calvert Townley, President of the American Institute of Electrical Engineers, presented an interesting historical sketch of the growth and development of electrical power as applied to the iron and steel industry. He pointed out that coöperation between

the various electrical societies was necessary in deriving the greatest benefits.

Much attention was attracted by an exhibition in which thirty-four manufacturers displayed electrical equipment.

American Foundrymen's Association

Remarkable advances in the design, development, and manufacture of metal-working and foundry equipment and in the solution of problems involved in casting practice and plant operation, were evidenced in the technical sessions and exhibition of the twenty-fourth annual convention of the American Foundrymen's Association, which was held in Philadelphia from September 29 to October 3 concurrently with the annual meeting of the Institute of Metals Division of the American Institute of Mining and Metallurgical Engineers. A significant feature of the convention was the attendance of more than a score of visitors from England, France, Norway, Japan, India, and Australia.

A paper on The Application of Powdered Coal to Malleable Annealing Furnaces, presented by Charles Longenecker, of the Bonnot Co., Pittsburgh, contained a description of the plant of the Pressed Steel Car Co., formerly the Pennsylvania Malleable Co., where powdered coal is being successfully employed for operating annealing furnaces. The figures quoted showed that the cost of operating one furnace ranges from $8400 a month with fuel oil to $2625 a month with powdered coal. That steel is being melted with 450 to 600 lb. of powdered coal per ton of charge and that 15 malleable foundries using powdered coal for annealing have a fuel ratio of from 500 to 700 lb. of coal per ton of castings was stated by A. J. Grindle, of the Combustion Economy Corporation, Chicago, who discussed the question of Powdered Coal for the Small Foundry.

Statements of costs covering the operation during four months of a 20-ton acid open-hearth furnace and a 6-ton basic electric furnace were compared and discussed by E. H. Ballard, of the General Electric Co., West Lynn, Mass. Mr. Ballard's figures showed that the cost of making electric steel is comparable with that of the open-hearth product. A. W. Merrick of the General Electric Co., Schenectady, N. Y., in the Refining of Cupola Malleable Iron in the Electric Furnace, presented the results of experiments on the duplex process of melting malleable cast iron, using a cupola and electric furnace. Special attention was paid to the effect of the electric furnace in reducing sulphur and to the influence of manganese. In one experiment the material contained 0.20 per cent sulphur before charging in the electric furnace; 15 minutes later a sample showed that the sulphur had been reduced to 0.057 per cent. Mr. Merrick offered several conclusions, among which was the statement that by the duplex process of melting malleable cast iron, using a cupola and electric furnace, it is possible to make iron of any carbon and silicon desired by adding the proper amounts of steel and ferrosilicon to the bath.

A special session was held to discuss the problem of industrial relations. The authors of four papers advocated systematic training for foundry apprentices, journeymen, and foremen along lines which will familiarize them with the economic conditions that play an important part in determining the administrative policies of the employers. The slogan "multiply yourself through your foreman," introduced by one of the speakers, impressed manufacturers as being a pertinent suggestion to remedy present conditions.

The exhibits of molding machines, sand-blasting equipment, and metal- and wood-working machinery furnished ample proof that engineers have taken full advantage of the cessation of hostilities to engage in experimental work and to further the development of labor-saving machines. Among the noteworthy machines displayed by the manufacturers of molding equipment was a device for producing tractor transmission housings entirely in green sand. Other new equipment included a combination split-pattern machine display, a jarring stripping-plate machine, an agricultural tractor, a 16-in. jolt roll-over machine fitted with a pattern and operated as a molding machine, and a combination jolt split-pattern molding machine equipped with an automatic slow-starting pattern-draft cylinder operated by oil and controlled by a knee valve.

American Institute of Mining and Metallurgical Engineers

The one hundred and twentieth meeting of the American Institute of Mining and Metallurgical Engineers was held at Chicago from September 22 to 26, inclusive. Exceedingly comprehensive and valuable papers were prepared for the twelve technical sessions, in which the subjects discussed were: Iron and Steel; Sulphur Coals; Pyrometry; Non-Ferrous Metallography; Non-Ferrous Metallurgy; Coal and Gas; Mine Taxation; Mining and Local Resources; Geology; Milling; Oil; and Industrial Organization. It will be of interest to call attention to some of the papers presented, especially at the iron and steel session.

A report of the work being done at the United States Bureau of Standards for the purpose of determining the gases in steel and the deoxidation of steel, was submitted by J. R. Cain, Chief of the Section of Chemical Metallurgy. The aim has been to examine critically some of the simpler methods in order to remedy any defects, to make them more rapid, and to form some idea of the metallurgical significance of the results obtained by them. The final object of the work, which is not altogether complete, is to devise a few simple methods which it is hoped will be useful to the steel manufacturer in controlling his deoxidation processes.

Erosion Tests of Rifle Barrels were described by Major A. E. Bellis, Ordnance Department. Three barrel blanks were prepared from the same bar of steel and treated differently. The first barrel was heat-treated by quenching from 1500 deg. fahr. and drawing for two hours at 1200 deg. fahr.; the second barrel was rolled at 1350 deg. fahr.; and the third barrel was rolled at 1200 deg. fahr. The three barrels were submitted to a 13,000-round firing test with measurements for accuracy and erosion. The accuracy was measured by firing ten rounds on each two targets at 500 yd. with muzzle rest; the tests were made after each 2000 rounds from 4000 to 10,000 and then every 1000 to 13,000; the firing was at the rate of 10 to 20 rounds per minute per rifle, cooling the rifles with water after each 100 rounds. The relative erosion was shown by the increase of diameter of the lands at the muzzle, which was 0.0018 in., 0.0020 in. and 0.0029 in. for the three barrels, respectively. After the tests the three barrels were sawn lengthwise and the appearances of the sections examined. It was concluded that the homogeneous structure of a heat-treated barrel offers the best resistance to erosion.

The results of an experimental study of the Effect of Time and Low Temperature on Physical Properties of Medium-Carbon Steel were presented by G. A. Reinhardt, metallurgist, and H. L. Cutler, assistant metallurgist, The Youngstown Sheet & Tube Co. In the first series of tests, four cores were drilled from each of six untreated blooms. Two cores from each bloom after being machined were rested for two days at room temperature, and then they were tested; the two duplicate cores after being machined were rested for two days on top of a Hoskins hairpin-type electric furnace where the temperature was kept at about 120 deg. cent. A second series of tests was also made in identically the same manner except that the test pieces were given a rest of four days before being tested. These two series of tests showed that a light increase in temperature resulted in a great increase of the possible elongation and reduction of area of the specimen, and also with the increased length of rest at the temperature of the top of the furnace. The increase in tensile strength was greater in the case of the two days' rest than in the case of the four days' rest.

Other interesting papers presented at the iron and steel session were: Blast Furnace Refractories, by Raymond M. Howe; Effervescing Steel, by Henry D. Hibbard; Aircraft Steels, by Albert Sauveur; Manufacture of Steel Rails, by Robert W. Hunt; Cooling Properties of Technical Quenching Liquids, by N. B. Pilling and T. D. Lynch; Differential Crystallization in Cast-Steel Runner, by Francis B. Foley; Manufacture and Properties of Light-Wall Structural Tubing, by H. J. French; Oxygen in Cast Iron and Its Applications, by Wilford L. Stork; Graphitization of White Cast Iron upon Annealing, by Paul D. Merica and L. J. Gurevich; Experimental Data Obtained on Charpy Impact Machine, by F. C. Langenberg.

ENGINEERING COUNCIL

Engineering Council[1] is an Organization of National Technical Societies of America, Created to Consider Matters of Common Concern to Engineers, as Well as Those of Public Welfare in Which the Profession is Interested

Engineering Council Joins Chamber of Commerce

WORD has been received by Engineering Council that the organization has been elected to membership in the Chamber of Commerce of the United States. In joining this great association of trade and commercial organizations, Engineering Council adds its strength to organized business and gives its members an opportunity to register their views with the central body in the consideration of national questions that affect business. Engineering Council represents five great national societies of professional engineers,— the American Society of Civil Engineers, the American Institute of Mining and Metallurgical Engineers, The American Society of Mechanical Engineers, the American Institute of Electrical Engineers and the American Society for Testing Materials. These societies have an aggregate membership of 41,000.

Engineering Council has appointed as National Councilor to represent it in the National Chamber, Mr. Harold W. Buck, of Viele, Blackwell & Buck, Consulting Engineers, New York City, and past-president of the American Institute of Electrical Engineers, and as alternate Mr. Irving E. Moultrop, of the Edison Electric Illuminating Company, Boston, Mass., member of The American Society of Mechanical Engineers and American Institute of Electrical Engineers.

The Chamber of Commerce of the United States was formed in 1912 as a means of bringing together all of the industrial and business elements of the country. How well it has succeeded is shown in a recent statement that the membership of the Chamber now consists of more than 1100 organizations in every state of the Union, in the outlying possessions and of all the principal American chambers of commerce abroad.

One of the chief aims of the National Chamber is to obtain the best thought on national questions that concern business. This is done through a system of referenda on which the more than half a million individual members of the organizations comprising the Chamber are entitled to vote through their associations. The opinion of business, thus obtained, is transmitted to Congress and to public officials and is given to the public.

The National Chamber will be able to render assistance to Engineering Council in many ways. It will receive weekly a general bulletin containing the latest and most authentic news of what is transpiring at Washington. There is also a special legislative bulletin issued weekly while Congress is in session following the progress of all legislation concerning business. Special bulletins are issued also as occasion arises. Members of the National Chamber also have the privilege of using all the facilities of the Chamber's offices in Washington when information is desired. This applies to every division of business, since the Chamber's organization is made up so that each general division of business has in Washington a special bureau to care for its particular needs.

Engineering Council Holds Important Meeting

On October 16, in the rooms of The American Society of Civil Engineers in the Engineering Societies Building, New York, Engineering Council held an all-day session, at which many matters of interest and importance were considered. Chief among these were reports of the Committee on Classification and Compensation of Engineers, the National Service Committee and the Committee on Curricula of Engineering Schools. Space will not permit, however, of an extended discussion of these and other reports, and for the present the brief abstract of the minutes of the meeting presented below must suffice.

The report of the Committee on Curricula of Engineering Schools, however, deserves special mention. Dr. Alexander C. Humphreys, President of Stevens Institute of Technology, is chairman, and while the committee is not prepared as yet to recommend a six-year course for colleges of engineering, it nevertheless called attention in its report to the fact that both Columbia University and the Massachusetts Institute of Technology are now conducting six-year courses in engineering in addition to their regular four-year course. The problem is also being studied and experimented with by other universities. The committee, however, does endorse the proposition to extend and enlarge the facilities for vocational training throughout the United States, and particularly in the great industrial centers. The committee also goes on record as favoring universal military training.

Employment Bureau reported 17,000 interviews, 4800 men registered, more than 1000 placed and total expenditure $10,600, in past 10 months; 60 to 70 men call daily.

National Service Committee active in connection with National budget legislation, Congressional Commission on Reclassification of Salaries, mileage for former engineer officers, Interstate Commerce Commission and International Joint Commission vacancies, Industrial Conference, census classification of engineers, U. S. Topographical Mapping and Department of Public Works. Washington office used increasingly by engineers and Government.

Chamber of Commerce has admitted Council to membership. H. W. Buck appointed National Councilor and Delegate, and I. E. Moultrop alternate.

National Department of Public Works: petition to Chamber of Commerce was voted by Engineering Council asking referendum on bill for Department of Public Works.

License Committee, at five-day session in Chicago, October 13 to 17, revised draft of typical law for registration of engineers.

Classification and Compensation of Engineers: progress in collecting and digesting data on Federal, Railroad, State and Municipal engineers. Final report on Federal service this month. Increases granted railroad engineers below $2500.

Fuel Conservation Committee recommended support of legislation for investigating super-power generation and distribution in Boston-Washington district; so voted.

Joint Conference Report of Development Committees was discussed and letters sent to Founder Societies endorsing general plan for a national engineering council.

Financial Statement: total resources, $50,393; expended, 9 months, $32,651, including $10,601 for Employment Bureau and $17,038 for Washington office.

Tentative Budget 1920: $60,000 needed for all purposes. Appropriations of Founder Societies must be supplemented by contributions from individuals.

Appeal for Funds to be made at once to engineers throughout the country.

Water Conservation Committee reported twenty-seven correspondents appointed in as many States, and much useful information collected.

Curricula of Engineering Schools: Committee reported on six-year course.

Reconstruction Commission, New York: Advisory Committee's recommendations sent to governors of all States and many civic bodies in New York.

Patents Committee: three bills, based on report of committees of National Research Council and Engineering Council, now before Congress.

Jurisdiction Awards in Building Industry: Board held first meeting in Washington August 11. Report by Council's representative, R. P. Miller.

Types of Government Contracts: important committee appointed.

Payment for Estimating: three delegates appointed to meet Associated General Contractors and American Institute of Architects, in Chicago.

National Budget: four delegates sent on invitation of committee of House of Representatives discussed budget legislation.

[1] Officers of Engineering Council: J. Parke Channing, *Chairman*, Alfred D. Flinn, *Secretary*; Engineering Societies Building, 29 West 39th Street, New York.

NATIONAL SERVICE COMMITTEE

Contributed by the Washington Office[1]

Engineering Legislation in Congress

Although Congress is chiefly engaged with problems relating to the Peace Treaty and the industrial unrest throughout the country, there have, nevertheless, been presented to it numerous bills and measures dealing particularly with engineering subjects. These bills deal with such matters as war minerals relief, soldiers' land settlement, tariff, water power, etc. Most of them are now being considered by the various committees of Congress and brief abstracts of them are herewith presented.

United States Reclamation Work

An appropriation of $250,000,000 for the purpose of carrying on and completing irrigation projects, which have been begun or estimated for and for the investigation and completion of such new projects as may be deemed feasible and desirable to undertake, is proposed in recent bills. According to the Director of United States Reclamation Service, it will cost $112,134,000 to complete projects that have been started. A total of 1,552,555 acres will be susceptible of irrigation, and the total ultimate irrigable area will be 2,948,161 acres.

Another important bill relating to irrigation work has had the special attention of the House. It proposes to allow water supply for reclamation projects to be used for miscellaneous purposes. Under the existing law, much inconvenience and trouble has been caused, owing to the fact that water for reclamation projects could not be used for domestic purposes, for railway engines and the miscellaneous needs of communities. This bill is expected to shortly receive consideration in the House.

War Minerals Relief

Legislation proposing to liberalize the War Minerals Relief Act is now before the Committee on Mines and Mining of the House. This Committee is considering House Joint Resolution No. 170, which brings out the fact that war minerals claims in excess of $15,000,000 had been filed but that a considerable portion of the claims are being denied because of the Attorney-General's interpretation of the Act. The resolution states that it was the intention of Congress in passing the War Minerals Relief Act "that all producers of the minerals mentioned should be repaid such sums as they are in equity and good faith entitled." The Attorney-General's opinion is that the request or demand must have been made on the claimant direct. The resolution provides that all claimants "who in response to any personal, written or published request or demand from any of the Government agencies mentioned in said Act in good faith expended money in producing or preparing to produce any of the ores or minerals named therein . . . and have heretofore filed their claims within the time and in the manner prescribed in said Act" are to be reimbursed for the net losses incurred. Another important feature of the resolution is that in the event that the appropriation is not sufficient to liquidate all claims allowed that a pro rata share of the appropriation is to be awarded to the claimants. Fifty per cent of the amount of any adjudicated claim is to be paid immediately.

Soldier Settlement Bill

The Mondell Soldier Settlement Bill, which is now before the House, is again coming actively to the front and determined efforts are being made to have it passed. Great differences of opinion have developed and the entire discussion on the soldier settlement plan seems now to be around the Mondell bill. Those who favor the bill point out the fact that it is the continuation of the historic policy of opening the way for the veterans of war to settle on the land. In the absence of public lands suitable for farming the acquisition of land in private ownership is necessary. It is argued that the bill comprises good business policy because tracts of poor land will be cleared, graded and irrigated. This is to be done by the soldiers, thus affording an opportunity to accumulate the amount of money required for the first payment on such property as may be alloted to them. Limited sums of money to be loaned for construction of permanent improvements to give a fair margin of security and at the rate of 4 per cent interest is held to be a reasonable income to the Government. Colonization of soldier settlers is necessary to proper Government supervision and to the securing of maximum economy and efficiency. Some action of this kind of legislation is apparently forced because of different schemes which have been suggested to either compensate veterans of the world war or to give them other opportunities.

Tariff Bill

When the House passed the magnesite tariff bill, it added one more to the jam of tariff bills awaiting action of the Senate Committee on Finance. As passed the bill provides a duty of one-half a cent per pound on magnesite ore; three-quarters of a cent on calcined dead-burned and grain magnesite, and three-quarters of a cent per pound and 10 per cent ad valorem. These rates represent a considerable reduction from the tariff proposed by the House Ways and Means Committee of three-quarters of a cent on ore, one and one-half cents on calcined dead-burned and grain magnesite and a duty of 25 per cent ad valorem on magnesite brick. The duties imposed are claimed to be high enough to prohibit imports of magnesite, and the increased rate would add only three and three-quarters cents per ton to the price of finished steel.

The question of a strong protective tariff on graphite is now before the House. The original writing of this bill provides a duty of two cents per pound on all imported amphorous graphites; a duty of three cents per pound on crystalline, lump and chipped graphite; and a duty of six cents on all large sizes of crystalline graphite. The first provision affects graphite produced in Mexico and Korea; the second provision affects the importation of the better grade of Ceylon graphite, while the last provision affects Madagascar and Canadian flake. The bill if enacted will practically exclude the importation of Canadian graphite and Madagascar flake.

The delay in considering the tariff bills before the Senate committee is due to the fact that it opposes "piece-meal" tariff legislation as it is conducted by the House, and they do not regard the matter of general revision of tariff with enthusiasm until such time as world conditions are in a more stable state. Many are of the opinion that the enactment of a general anti-dumping bill would protect American interests until it is possible to form a better idea of international trade relationships.

The United States Tariff Commission in reporting to the Committee on Ways and Means pointed out the fact that it would be unfair to group all scientific instruments together and place a blanket duty on them. And this, they say, is just an example of the plan to adapt a general tariff. Investigations further show that, in many cases, superior articles are now produced in the states to those formerly imported.

Machine Tools for Technical Institutions

Recently, the House passed a bill authorizing the Secretary of War to sell to schools, universities and colleges surplus machine tools which could be used for educational purposes. The educational institutions were to be charged 10 per cent of the original cost of these tools.

The Senate Committee on Military Affairs has now reported another bill authorizing the Secretary of War to transfer permanently to the Federal Board for Vocational Education, about $250,000 worth of this equipment. Surplus machine tools are to be loaned to the board, which, in turn, distribute them to schools and colleges throughout the country. This bill proposes to place

[1] Washington Office in charge of M. O. Leighton, *Chairman*, National Service Committee, McLachlen Building, 10th and G Streets.

the title to these machines in the hands of the Vocational Board, which is to report to Congress annually as to the disposition and use of the tools.

Water Power Bills

Engineering Council through its Water Conservation Committee is making determined efforts to assist in passing a bill (H.R. 3184) which will give the country good water-power legislation. The interest shown by requests for exact information on this bill indicates that the active interest and support required will be given by engineers. It is hoped that opposition to the bill, led by Wisconsin senators, will be broken through the influence of Wisconsin engineers.

The bill as reported to the Senate contains several important changes in the text of the bill passed by the House but these are not fundamental changes, and it is contemplated that the House will concur. The Senate Committee has explained and clarified the definitions of "reservations," "navigable waters" and "costs." A proportionate license fee not exceeding twenty-five cents per horsepower is proposed, which is to defray costs of the administration of the act. Fair rentals are to be charged for Government dams and other Government property on water-power sites. The House bill gave the Commission unlimited power to fix annual charges, whereas the Senate amendment limits this blanket power as indicated above. A change was made to provide that in case the United States does not exercise the right to take over the works, the license tendered shall be "on reasonable terms" and "which is accepted" by the original or the new licensee. That provision was thought necessary to make it certain that capital would invest under the law. A provision for severance damages was stricken out by the sub-committee and was restored by the full committee, so that it now appears in the bill.

Delay faces the action on this bill because past efforts to have immediate consideration indicate that it must await the disposal of the Peace Treaty before it comes up for consideration on the Senate floor. In reporting the bill to the Senate calendar, Senator Jones of Washington, chairman of the Committee on Commerce, pointed out its advantages as: "a saving of coal and a lower price for that used; a saving of oil, and a lower price for that consumed; more efficient transportation, and lower cost of service; the development of new industries; the building up of new communities; the creation of new property values, subject to taxation for the support and maintenance of local and state governments; and added employment for labor and increased markets for agricultural products," and urged that "we should pass legislation which will lead private capital and enterprise to develop these resources under such regulations as will give consumers good service and cheap power or the Government itself should proceed to make this development." This bill proceeds on the theory of private development with ultimate public ownership possible. While some of the fundamental provisions of this measure do not meet the approval of the members of the committee, we deem it wise to accept them in view of the legislative situation, rather than incur the result of no legislation on this important subject.

Budget Legislation

Through the National Service Committee of Engineering Council arrangements were made for the Public Affairs Committee and other representatives of Engineering Council to appear before the Select Committee on the Budget on October 1. Mr. Charles Whiting Baker, chairman of Council's Public Affairs Committee, gave reasons for the general desire among engineers for the adoption of a budget system, and pointed out the importance of such a system in Government work of an engineering nature. Mr. N. P. Lewis, Chief Engineer, Board of Estimate and Apportionment, New York City, explained the budget system as used in New York, showing that under existing conditions it would practically be impossible for New York to get along under any other system. Director and Chief Engineer of United States Reclamation Service, Mr. A. P. Davis, pointed out the necessity of the proper segregation of Government bureaus before an effective budget system can be adopted, and as a correct example of segregation, cited the plan proposed in the Jones-Reavis bill, whereby all related bureaus having engineering activities would be placed in the same department. Such a plan would simplify and make possible the efficient use of the budget system and of lump sums appropriation where responsible department heads could be obtained. Mr. W. R. Warner of the Warner-Swasey Company, Cleveland, pointed out the great advantages that had accrued to private engineering operations through the use of the budget system. It was pointed out during the hearing that engineering work was particularly hampered by the present system of appropriation. The lump sum or "continuing contract" method was held to be necessary in many cases. Illustrations of the success of the plan are the Panama Canal, levee work being done on the Mississippi River and the large reclamation projects.

There are obviously three phases of budget legislation: (1) formation of budget, (2) action on budget by Congress, and (3) supervision and control of the execution of budget. A new bill has been introduced and reported to the House calendar which aims to cover the first and third phases, while the second phase is to be cared for by House legislation which proposes a much larger appropriation committee to care for the budget in Congress. The main bill provides executive responsibility for the budget with Congressional authority to raise or lower it. The President, assisted by the Bureau of the Budget, is to prepare the estimates, which are submitted to him by the several executive departments, and no other officer is to submit estimates to Congress unless by special request. Provisions are made for an alternate budget in which estimates are to be made in the same form as they appear in current appropriation laws. The bill provides an independent establishment known as Accounting Department, because it is deemed necessary that Congress should have a check on expenditures under the direction of comptroller general and assistants, which would not be effective if the comptroller was appointed by the President. In reporting this bill, the chairman of the Select Committee on the Budget has explained that the bill is not intended to be the last word in budgetary legislation but is intended to correct weaknesses and to be a step in the right direction which will very probably have to be extended and further improved.

Engineers in the 1920 United States Census

As a result of Engineering Council's request to the Director of the Census, the National Service Committee has been successful in effecting a reclassification of engineers so that all technical engineers will be listed as such, separately and distinctly from the non-technical engineers. Thus, the next census will bring on enumeration of all technical engineers together as one unit under the main headings of Civil, Mechanical, Electrical, and Mining. Architects will also be enumerated separately.

This will enable the engineering profession, the Government or any other interested organization or person to know exactly how many technical men there are in the United States and in each State. Under separate headings the enumeration will also include non-technical engineers (stationary engineers, locomotive drivers and other engine-men); but there will be no group heading for the latter, and in order to get the totals of non-technical engineers (enginemen) all of the various grades of this classification would have to be sorted out and added.

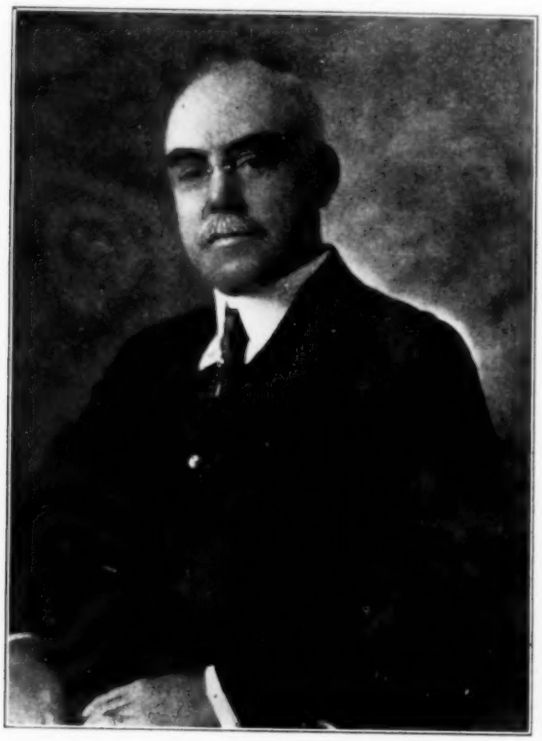
There are of course many practitioners of engineering who do nor ordinarily classify themselves under any one of the four headings given above and others there are whose practice extends into more than one field. More numerous headings or more complex classification is impracticable in the work of the Census Bureau. It is believed that every professional engineer can, with very little violence to the facts, place himself in one of the broad classes adopted for the 1920 census: Civil, Mechanical, Electrical, Mining. With the general coöperation of all engineers along these lines a much better enumeration should result than in any preceding census.

NECROLOGY

CHARLES EDWARD LORD

Charles Edward Lord, general patent attorney and manager of the patent department of the International Harvester Company, Chicago, died suddenly on September 25, as the result of injuries received in an accident at the Deering Works the evening before.

Mr. Lord was born in Somerville, Mass., on October 31, 1875, attended the public and high schools at Somerville, and was graduated from the Massachusetts Institute of Technology with the degree of B.S. in 1898. For a year he was employed in the inspection department of the American Telephone and Telegraph Company, with headquarters at Philadelphia. He then returned to the Massachusetts Institute of Technology as instructor for a short time, and later became assistant examiner in the United States Patent Office, Washington, D. C.



CHARLES E. LORD

In 1902 he entered the employ of the General Electric Company as assistant attorney in the patent department, which position he resigned in 1904 to take charge of the patent departments of the Bullock Electric Manufacturing Company and the Allis-Chalmers Company, spending four years at Cincinnati and four years at Milwaukee in this work. During part of this period he was president of the Bullock Electric Company.

He studied law at the Georgetown University Law School, Washington, D. C., was admitted to the bar in Ohio, Wisconsin and Illinois and to practice in the federal courts and in the Supreme Court of the United States.

Mr. Lord was associate editor of the Encyclopedia of Engineering and wrote several textbooks for this publication when it was getting under way. He was a lecturer on patent law at Marquette University, and during the days of the War was a member of the War Committee of the Technical Societies of Chicago. For two years and until recently he was chairman of the committee on patents of the National Implement and Vehicle Association.

During 1918 he served as chairman of the Chicago Section of our Society and at the time of his death was a member of the Committee on Aims and Organization, in the work of which he took a keen and active interest. He was also interested in the pioneer movement inaugurated by the Western Society of Engineers, in Chicago, for a strong and all-embracing local engineering society in that city.

His ability as an inventor, though not widely known, is evidenced by a record of nearly forty United States patents.

Mr. Lord was a fellow of the American Institute of Electrical Engineers, a member of the Society of Automotive Engineers, the Engineers' Club of Chicago, the American Patent Law Association, the University Club of Washington, D. C., and several other technical and social organizations. He became a member of our Society in 1909. [F.F.F.]

The following resolution was adopted by the executive committee of the Chicago Section:

> WHEREAS: Our fellow-member and former chairman of the Chicago Section, A.S.M.E., Mr. Charles E. Lord, who has served devotedly and who has sacrificed much in the interests of the mechanical engineers of the country, the Society and Section, has unfortunately been taken from us in the midst of a useful and active career; be it
>
> *Resolved*, By the Executive Committee of the Chicago Section that we record our deep regret at the loss of our friend and fellow-engineer. That we wish to express our appreciation of his high qualities, his interest in his profession, and the untiring zeal with which he has labored for its advancement and of its members, his great ability and high attainments. Be it further
>
> *Resolved*, That we express to his family and his associates in business our appreciation of his worth and our sincere sympathy with them in their loss.
>
> Executive Committee, Chicago Section,
>
> ARTHUR L. RICE, *Chairman*,
> G. R. BRANDON, *Secretary*.

A similar resolution was passed by the Committee on Aims and Organization upon the receipt of the news of Mr. Lord's death.

JAMES WEBSTER CULLEN

James W. Cullen, First Lieutenant, Signal Corps, United States Army, died suddenly on June 28, 1919, shortly after his return from service overseas. Lieutenant Cullen was born on March 15, 1888, in Edgewater, a suburb of Chicago. He was educated in the schools both of that city and Hamilton, Ohio, later attending the Miami and Ohio State Universities. He was formerly connected with the Niles Tool Works, the Cullen & Vaughan Construction Co. and the Midvale Steel Company, having charge of the Pittsburgh sales office of the latter concern. He resigned from the sales department of the Elwell-Parker Company to enter the service, serving both in France and Italy.

Lieutenant Cullen was a member of the Chamber of Commerce of Pittsburgh and of several clubs and fraternal organizations. He became an associate-member of the Society in 1916.

FRANK J. LOGAN

Frank J. Logan, who, until his retirement in 1914, was vice-president and treasurer of the Logan Iron Works, Brooklyn, died on April 10, 1919. Mr. Logan was born on September 25, 1855, in Brooklyn, N. Y. He was educated in the public schools of the city and later attended the Flushing Institute and Cooper Union. He started work with his father in the Logan Iron Works. At the time of his father's death, in 1879, Mr. Logan entered the firm and continued with them until his retirement, May 1, 1914.

Mr. Logan belonged to a number of social clubs and business organizations. He became a member of the Society in 1894.

LOUIS MOHR

Louis Mohr, president and consulting engineer of John Mohr & Sons, Chicago, died on August 24, 1919. Mr. Mohr was born on September 27, 1858, in Chicago and was educated in the schools of that city prior to his entering the University of Illinois, where he completed in three years a four-year course in mechanical engineering. He was connected for short periods thereafter with the North Chicago Rolling Mills and the Old Excelsior Iron Works. In 1882 he associated himself with his father and brothers in the firm of John Mohr & Sons as consulting engineer. About ten years later he assumed the duties of secretary of the firm and from 1917 to the time of his death held the office of president.

Mr. Mohr was a member of the American Society of Naval Engineers, the American Institute of Mining Engineers, the Society of Western Engineers and a large number of other societies and clubs. He became a member of our Society in 1886.

LLOYD CECIL REYNOLDS

Lloyd C. Reynolds was born in Atglen, Pa., on November 20, 1893. He received his early education in the local schools and later entered Drexel Institute, taking the mechanical-engineering course, from which he was graduated in 1913. He was associated from 1913 to 1916 with the Overland Motor Company, Philadelphia, the Chambersburg Engineering Company, Chambersburg, Pa., and the Remington Arms Company, Eddystone, Pa. From July 1916, to the time of his death, January 6, 1919, Mr. Reynolds was employed as assistant engineer in the steam-engineering department of the Midvale Steel & Ordnance Co., Coatesville, Pa.

Mr. Reynolds was a member of the Drexel Club of Engineers. He became a junior member of the Society in 1917.

JAMES R. FLETCHER

James R. Fletcher, factory manager of the P. & F. Corbin Co., manufacturers of hardware, New Britain, Conn., died at his home in that city on September 13, 1919. Mr. Fletcher was born on February 21, 1867, in Jersey City, N. J., where he was educated and learned the

J. R. FLETCHER

trade of machinist. He served his apprenticeship with the New Haven Clock Company in tool making and die sinking. He was formerly associated with the American Cash Register Company, the National Cash Register Company, Sargent & Co., the New Britain Hardware Company, of which he was in charge for seven years, and the Yale & Towne Manufacturing Co., of which he was assistant superintendent.

In 1906 Mr. Fletcher became associated with the P. & F. Corbin Co. as manufacturing expert to assist the general superintendent. Later he was made factory manager, a position created to give him the wider range warranted by his exceptional ability.

He was a member of a number of fraternal organizations. He became a member of the Society in 1906.

HUGH M. WILSON

Hugh M. Wilson, who, until his resignation in January 1917 was for six years first vice-president of the McGraw Publishing Company, died suddenly on September 19, at his home in Stockbridge, Mass. Mr. Wilson was born in June 1866, in Jacksonville, Ill. He was a graduate of the Illinois College. His first journalistic work was as a reporter for the daily press of the Middle-West. He was subsequently connected in varying capacities, including secretary, business manager, editor and president with the *Mississippi Valley Lumberman*, the *Northwestern Railroader*, the *Railway Age*, and the *Electric Railway Review*. After a year with the Barney & Smith Car Co., Dayton, Ohio, as vice-president in charge of sales, Mr. Wilson joined the McGraw Publishing Company.

Mr. Wilson became an associate of the Society in 1913.

RICHARD HAMMOND

Richard Hammond, former president of the Lake Erie Boiler Works and the Lake Erie Engineering Works, died on October 9, 1919. Mr. Hammond was born on January 27, 1849, in Thurles, Tipperary County, Ireland, and received his early education there in the parochial schools, coming to this country at the age of thirteen. He served his apprenticeship in the boiler-making trade in Troy, N. Y. In 1872 he moved to Titusville, Pa., and several years later bought out his partner's interests in an oil-well boiler and manufacturing business.

In 1880 he went to Buffalo and established the Lake Erie Boiler Works which soon obtained an unusual reputation for the manufacture of heavy marine boilers. In 1890 he organized the Lake Erie Engineering Works, the shops of which were equipped with the most modern tools especially designed and constructed according to Mr. Hammond's own specifications by the Niles Tool Works. He continued at the head of both concerns until 1917 when he retired from active business life.

Mr. Hammond was a member of the Engineer's Club of New York. He became a member of the Society in 1890 and devoted a great deal of his time and practical boiler-manufacturing experience to the Boiler Code Committee of the Society of which he was a member.

CYRUS T. RAYNER

Cyrus T. Rayner was born in New York City on January 28, 1879. He was educated in Southern schools and was graduated from Tulane University in 1902 with the degree of M. E. He spent one year in graduate work when he became connected with the Mississippi River Commission as junior engineer in charge of local surveys. From 1911 to 1912 he was associated with C. T. Rayner & Sons, consulting engineers. In 1912 he became first assistant engineer on the New Orleans Levee Board and four years later was made chief engineer, which position he was holding at the time of his death, January 19, 1919.

Mr. Rayner became a member of the Society in 1916.

OIL PIPE LINES

(*Continued from page 883*)

$$\text{Net hp.} = 17 \times \text{thousands of bbl. per day} \times P/1000$$
$$\text{B.hp.} = 20 \times \text{thousands of bbl. per day} \times P/1000$$

Since the horsepower varies directly as PQ and P varies directly as Q^2, it follows that hp. varies directly as Q^3.

Another relation of value in making rapid pipe-line calculations is the ratio between the diameter D and length L with the discharge Q and the pressure P remaining constant. From the friction formula [2], it will be seen that P varies directly as v^2L/D. Assuming P constant, L varies directly as D/v^2. For the same discharge, Formula [3], that is with Q constant, v varies directly as $1/D^2$. Therefore v^2 would vary directly as $1/D^4$. Substituting this value for v^2 above, it is seen that L varies directly as $D/(1/D^4)$, or in other words, L varies directly as D^5. This means that for the same discharge and pressure, i. e., the same friction, the length of the line would vary directly as the fifth power of the diameter.

Taking 6 in. as unity the fifth powers of several different diameters are as follows:

D =	6	8	10	12
D^5 =	1.0	4.2	12.8	32

An example will show how easily these relations are utilized. Let a proposed pipe line be made up as follows:

2 —	6-in. lines,	8 miles long	(Y-branch)
1 —	6-in. line,	6 miles long	
1 —	8-in. line,	10 miles long	
1 —	12-in. line,	12 miles long	

With the particular oil to be transported the pressure per mile when pumping 10,000 bbl. a day through a 6-in. line will be assumed as 20 lb. per mile. What, now, will be the pressure for 17,000 bbl. per day through above line and what will be the net hp. and b.hp. required?

Since P varies as Q^2, the pressure for 17,000 bbl. will be $\left[\frac{17{,}000}{10{,}000}\right]^2$ or 2.89 times the pressure for 10,000 bbl. The pressure in the line would then be 2.89×20 or 57.8 lb. per mile.

Inasmuch as the velocity is halved when using two 6-in. lines for the 8-mile section, each line carrying an equal amount of oil, the equivalent length of 6-in. line for each branch would be only two miles, the length varying directly as the square of the velocity. The length of 6-in. line equivalent to the 8-in. pipe would be 10 miles divided by the ratio of the fifth powers of the diameters 6 in. and 8 in. or $10/4.2 = 2.38$ miles. In a like manner the length of 6-in. line equivalent to the 12 miles of 12-in. pipe would be $12/32$ or 0.37 miles. In other words, the equivalent length of 6-in. pipe in the line under consideration would total 12.75 miles. Under a pressure on the line of 57.8 lb. per mile, the total pressure on the line would be 12.75×57.8 or 737 lb.

Making use of the simple formula for hp. already derived we have

$$\text{Net Horsepower} = 17 \times \frac{17{,}000}{1000} \times \frac{737}{1000} = 213$$

$$\text{Brake Horsepower} = 20 \times \frac{17{,}000}{1000} \times \frac{737}{1000} = 250$$

No doubt many other useful relations could be derived for the purpose of expediting pipe-line calculations, but those which have been presented are among the most useful.